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FOR THE

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REPORT

OF THE

BOARD ON FORTIFICATIONS OR OTHER DEFENSES

APPOINTED BY THE

PRESIDENT OF THE UNITED STATES

UNDER THE PROVISIONS OF

THE ACT OF CONGRESS

APPROVED MARCH 3, 1885.

WILLIAM C. ENDICOTT,
SECRETARY OF WAR,
PRESIDENT.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1886.

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CONTENTS.

	Page.
Letter from the Secretary of War transmitting to the Congress the report of the Board	3
Order of the President appointing the *personnel* of the Board	5
Report of the Board	5
REPORT OF COMMITTEE No. 1, to collect information and report upon the various kinds of armor, the penetration and effects of shot upon armor, and earth, and guns and their ranges	31
Report of subcommittee on armor, guns, and their ranges, &c., with tables of dimensions, weights, trials, &c	34
REPORT OF COMMITTEE No. 2, being appendix to report of Committee No. 1, to collect information and report upon torpedoes, stationary and movable, and torpedo boats	67
Appendix to report of Committee No. 2, on submarine boats, by Capt. Edward Maguire, Corps of Engineers	77
REPORT OF COMMITTEE No. 3, to collect information and report upon ships of war, their armor, armament, and draught of water; also the navigable draught of entrances of the ports of the country	101
INCLOSURE A.—Characteristics of principal foreign ships of war	105
INCLOSURE B.—Depths of water on bars	160
INCLOSURE C.—List of vessels classified according to draught of water, and the ports which they can enter	161
INCLOSURE D.—Characteristics of principal ports of the United States	169
INCLOSURE E.—Study of exposed points on our frontier; lines of communication and possible bases of hostile operations	193
REPORT OF COMMITTEE No. 4, to collect information and report upon the capacity of the country to furnish armor and guns, and the steps necessary to enlarge that capacity	257
APPENDIX A.—List of steel works as reported to August, 1885, to American Iron and Steel Association	273
APPENDIX B.—Iron and compound armor plates	277
Floating batteries—appendix to report of Committee No. 5	305
General features of a first-class coast-defense vessel, designed for service in open bays or deep channels, and to fight in any weather	319
General features of a first-class coast-defense vessel designed for service in open bays and deep channels, to fight in heavy weather, with draught of water determined with special reference to service in the Chesapeake Bay	329
General features of a second-class coast-defense vessel designed for general service on the coasts of the United States, or for offensive operations in neighboring waters	337
General features of a light-draught harbor-defense gunboat, designed for service in shallow bays and narrow channels, to carry a single armor-piercing gun, which may be fought in such waters in moderate weather	345
Lake, river, and harbor gun, and torpedo boat—general features	351
Particular features of proposed coast-defense vessels	355
REPORT OF COMMITTEE No. 6, to collect information on gun-carriages	359
APPENDIX 1.—Description of Brewers counterpoise platform	363
APPENDIX 2.—Proposed depressing gun-carriage, by Lieut. Col. A. R. Buffington, Ordnance Department.	367
APPENDIX 3.—Memorandum by Maj. W. R. King, U. S. Engineers, on the counterpoise gun-carriage designed by him in 1868, and its recent adaptation to the requirements of modern heavy ordnance	371
APPENDIX 4.—Josiah Vavasseur's apparatus for controlling the recoil of ordnance	385
APPENDIX 5.—Lieut. Col. Malet's patent gun-carriage designed for the U. S. Government; pattern 5-inch 30 cal. B. L. R. gun	387

LETTER

FROM

THE SECRETARY OF WAR,

TRANSMITTING

The report of the Board on Fortifications or other Defenses, appointed under act of March 3, 1885.

JANUARY 26, 1886.—Referred to the Committee on Appropriations and ordered to be printed.

WAR DEPARTMENT,
Washington City, January 23, 1886.

The Secretary of War has the honor to transmit to Congress, with the appendices accompanying the same, the report of the Board on Fortifications or other Defenses, appointed by the President under the following provision of the act of Congress approved March 3, 1885:

The President of the United States shall appoint a Board, of which the Secretary of War shall be a member and president, to be composed of two officers of the Engineer Corps, two from the Ordnance Corps, two officers of the line of the Navy, and two civilians, which Board shall examine and report at what forts fortifications or other defenses are most urgently required, the character and kind of defenses best adapted for each, with reference to armament; the utilization of torpedoes, mines, or other defensive appliances, and for the necessary and proper expenses of said Board and for the compensation of the two civilians at $10 per day while so employed in the discharge of said duty, the sum of $40,000, to be immediately available, is hereby appropriated; and the report of said Board shall be transmitted to Congress by the Secretary of War.

WM. C. ENDICOTT,
Secretary of War.

The SPEAKER OF THE HOUSE OF REPRESENTATIVES.

REPORT OF THE BOARD.

ORDER OF THE PRESIDENT.

EXECUTIVE MANSION, *Washington, May* 12, 1885.

Under a provision of an act of Congress entitled "An act making appropriations for fortifications and other works of defense, and for the armament thereof for the fiscal year ending June thirtieth, eighteen hundred and eighty-six, and for other purposes," approved March 3, 1885, a Board, to consist of the officers and civilians hereinafter named, is appointed to "examine and report at what ports fortifications or other defenses are most urgently required, the character and kind of defenses best adapted for each, with reference to armament," and "the utilization of torpedoes, mines, or other defensive appliances:"

Hon. William C. Endicott, Secretary of War, president of the Board.
Brigadier-General Stephen V. Benét, Chief of Ordnance.
Brigadier-General John Newton, Chief of Engineers.
Lieutenant-Colonel Henry L. Abbot, Corps of Engineers.
Captain Charles S. Smith, Ordnance Department.
Commander W. T. Sampson, U. S. Navy.
Commander Caspar F. Goodrich, U. S. Navy.
Mr. Joseph Morgan, jr., of Pennsylvania.
Mr. Erastus Corning, of New York.

GROVER CLEVELAND.

The Board convened by order of the President has the honor to submit the following report:

The reports of the Chief of Engineers of the Army have annually laid before the country the condition of the national defenses, and attention is specially invited to those of 1880, 1881, 1882, and 1884.

Without enlarging upon this subject, it suffices to state that the coast fortifications, which in 1860 were not surpassed by those of any country for efficiency, either for offense or defense, and were entirely competent to resist vessels of war of that period, have, since the introduction of rifled guns of heavy power and of armor plating in the navies of the world, become unable to cope with modern iron or steel-clad ships of war; far less to prevent their passage into the ports destined for attack.

Prior to 1860 the largest gun in service was the 10-inch Rodman smooth-bore, the energy of whose projectile was 2,000 foot-tons. The forts of that period were more than competent to resist its projectile; it should form, therefore, no subject of reproach because at present they cannot withstand the shock of 20,000, 30,000, and 45,000 foot-tons of energy, without mentioning the new guns under construction expected to deliver 61,000 foot-tons of energy. On the other hand, the assumption should not be made that existing fortifications may not be effective at short range

against unarmored or light armored ships. At many sites, also, they are of indispensable value as citadels or keeps to secure the position against attacks by land, and as flanking works for torpedo lines.

Some idea of the wonderful change in guns since 1860 may be obtained from comparing the weights of the projectiles, which, during this period, have increased about twenty-fold. This increase in power of guns necessitates the use of large masses of armor in important parts of the defensive works and largely increases their cost compared with the old works.

It is of no advantage to conceal the fact that the ports along our sea-coast—a length of about 4,000 miles, not including Alaska—invite naval attack; nor that our richest ports, from their greater depth of water and capacity to admit the largest and most formidable armored ships, are of all the most defenseless.

The property at stake exposed to easy capture and destruction would amount to billions of dollars, and the contributions which could be levied by a hostile fleet upon our sea-ports should be reckoned at hundreds of millions.

It is impossible to understand the supineness which has kept this nation quiet—allowing its floating and shore defenses to become obsolete and effete—without making an effort to keep progress with the age, while other nations, besides constructing powerful navies, have not considered themselves secure without large expenditures for fortifications, including armored forts.

Our nearest neighbor, though reasoning from the past, she should have no occasion to dread a naval attack from us, has nevertheless constructed armored forts at Halifax and Bermuda, both as a refuge for her fleets and as outposts for offensive operations.

In the mean time we have acquired great riches and apparently dreamed that prosperity should inspire friendship and not envy in less favored peoples—forgetting that riches are a temptation, and that the plunder of one of our sea-ports might abundantly reimburse an enemy for the expenses of a war conducted against us.

Had another policy prevailed and been consistently pursued towards the formation of a suitable coast defense, we should at the present moment have nothing more serious to engage our attention than a measured development in the strength of the works of defense and in the power of guns, in order to keep pace with the gradual progress in the means of attack.

Unfortunately the immense labor of novel constructions must be undertaken, under circumstances where careful workmanship is required and haste would be impossible. Under the most favorable conditions a long period would be required to place the defense upon a secure basis, and who shall guarantee that this can be effected free from complications with foreign powers? The Gun-Foundry Board has estimated that it would require at least three years to establish proper plant for the construction of modern guns. It would in all probability require two years more to get out and prove the first 16-inch gun That there may be no delay in mounting the guns as fast as completed, the work upon the extensive foundations for the gun emplacements, as well as magazines, shell-rooms, engine-rooms, and other constructions necessary for the service of the guns, should be commenced at the earliest moment.

WHERE DEFENSES ARE MOST URGENT.

The first in the order of the duties imposed upon the Board is "to examine and report at what ports fortifications or other defenses are most urgently required."

Preliminary to a decision upon this important matter, it is proper to discuss briefly the objects to be secured by a defense of the coasts, and the nature of the attack to which these are most exposed.

To the last named the answer would be—a naval attack. An attack by land, if attempted in force, must be resisted by the armies of the country, and the mode of doing this it is not necessary here to consider.

The objects against which a naval attack would be directed are—

First, the important commercial ports, containing, in addition to the shipping, large magazines of the products of commerce, and which are, on account of public and private wealth, tempting marks to an enemy. Such cities are also railroad centers, and their capture by an enemy would derange not only the internal commerce by land, but also interfere with the transportation of troops and *matériel* of war; and this might occur at critical junctures during military operations. And if, in addition, these places should be the sites of navy-yards, naval stations, and of depots of military and naval stores, the loss and injury to the country would be greatly increased.

In the second place, vessels in the foreign trade must be protected—this at sea could be performed only by the Navy—but when these arrive upon the coast, they should find fortified harbors of refuge provided for their security.

The third object of attack and capture would be the vessels employed in the coasting trade. A glance at the map of the coast will clearly indicate the dangers to which this commerce is exposed. An enemy having superior naval power might intercept all communication coastwise between New York and the ports of New England, by cruising in Vineyard and Long Island Sounds. His cruisers watching Sandy Hook, the mouths of Delaware and Chesapeake Bays, the coasts of Georgia and the Carolinas, the Florida straits and the Gulf coasts, would subject this trade to such risk of capture, that during war it would be virtually suspended. Nor could this result be prevented by our Navy, even if provided with more numerous and more suitable vessels than past experience would seem to insure, because of the immense stretch of the coast and of the crowd of fast cruisers and of privateers which could be let loose to capture and destroy. When the country shall have been provided with a few fast cruisers, their employment should be in depredating upon the enemy's property and commerce, instead of engaging in a futile attempt to protect the coasting trade over a line extending for 4,000 miles. Experience has also taught us that a few Confederate privateers sufficed to annihilate or suspend our commerce upon the seas, and we should be ready to apply the lesson so taught to an enemy's commerce.

By the suspension of the coasting trade the lines of interior navigation would become of importance. The meaning must be restricted here to the portions of those lines where a hostile vessel could not easily penetrate, and hence would only include the route from New York to Baltimore by canal and otherwise; that from Norfolk to Beaufort, N. C.; and that from Savannah to the Saint John's River, though this last-named line might be penetrated at several points.

The subject of the defense of the coasts has usually been treated upon the supposition of the existence of a navy not equal to the fleets of the enemy, but sufficiently numerous to impose upon him the necessity of concentration and the avoidance of large detachments from his force, but this view of the case the Board is not called upon to discuss, for it does not exist, and it will besides be found in the sequel that some of the ports named for defense will be strategic rendezvous for fighting ships of war, when these shall have been built in adequate numbers for operating in force against the enemy.

PORTS ARRANGED IN ORDER OF URGENCY.

1. New York.
2. San Francisco.
3. Boston.
4. The Lake ports.
5. Hampton Roads.
6. New Orleans.
7. Philadelphia.
8. Washington.
9. Baltimore.
10. Portland, Me.
11. Rhode Island ports in Narragansett Bay.
12. Key West.
13. Charleston, S. C.
14. Mobile.
15. New London.
16. Savannah.
17. Galveston.
18. Portland, Oreg.
19. Pensacola, Fla.
20. Wilmington, N. C.
21. San Diego, Cal.
22. Portsmouth, N. H.
23. Defenses of Cumberland Sound at Fort Clinch.
24. Defenses of ports of the Kennebec River, Me., at Fort Popham.
25. New Bedford, Mass.
26. Defenses of ports on the Penobscot River, Me., at Fort Knox.
27. New Haven, Conn.

The list of ports is not exclusively arranged n the order of commercial importance—some reference being had to the facility of defending certain sites, and the greater or less period of time which this task might demand. Baltimore, Savannah, Wilmington, and others belong to the class where in an emergency obstructions might be improvised to check temporarily a hostile squadron.

It is not possible to arrange the smaller ports always in the order of importance, also, because the necessity of a fortified harbor of refuge may be more urgent upon a long stretch of exposed coast, although the port there situated might be inferior in wealth and importance to others to which it has been preferred.

The Board, in limiting the list to the names above, does not wish it to be understood that there are no other places along the coast which are of the importance necessary to justify measures of defense. There are others, but the works of defense already existing at some of these, and the force of any probable attack which would be directed against them, do not make it necessary to call particular attention at this time to their condition and needs.

The Board, in stating "at what ports fortifications or other defenses are most urgently required," presents the following list:

1. New York.
2. San Francisco.
3. Boston.
4. The Lake ports.
5. Hampton Roads.
6. New Orleans.
7. Philadelphia.
8. Washington.
9. Baltimore.
10. Portland, Me.
11. Rhode Island ports in Narragansett Bay.

THE DEFENSES AND THEIR ACCESSORIES.

In the sequel the objects to be gained by the defense of the principal ports, as well as of others named in this report, will be commented upon. The Board will

now consider "the character and kind of defenses best adapted for each, with reference to armament" and "the utilization of torpedoes, mines, or other defensive appliances," taking up the subject in the order in which it is presented to it.

The defenses, as to character and kind with reference to armament, should be fixed and floating, one or both, according to locality, armed with powerful cannon needed to repel attack from the most formidable ships.

In the phrase "floating defenses" just used, the armored sea-going ship of the Navy is not referred to. We have none of that kind, and if hereafter built in sufficient number and power they would act offensively and not be confined to the defense of ports. The floating defenses mean floating batteries designed specially for operating in harbors or close to the land—armored more heavily and armed with heavier guns than any probable adversary. Of considerably less draught than the armored sea-going ship they could, by operating among the shoals, avoid ramming, and even torpedoes. To gain such advantages speed must be sacrificed, but it is quite evident that for the defense of harbors and bays the advantages of extra thickness of armor and of superior power of gun more than compensate for that loss. These batteries are costly, and their use should be restricted to cases of necessity; as, for instance, where the port is so near to deep water that a bombardment may not otherwise be prevented; also in localities where the nature of the foundations forbids the construction of fixed defenses, or where the width of the channel is too great to be well swept from shore batteries. Besides the floating batteries hereinafter specifically recommended, the Board desires to point out that while not required at present, others may be useful to guard the eastern end of Long Island Sound and the approaches on that side to New York, and in Chesapeake Bay as an outer line of defense to Baltimore, Washington, and Hampton Roads.

The shore batteries may be armored turrets revolving or fixed, armored casemates, and emplacements in barbette. The materials used in construction for the armor might either be iron or steel, although the latest experiments indicate the superiority of forged steel plates. While the Board is of opinion that forged steel plates should be used, it also recommends that immediate experiments be undertaken to determine the most suitable armor for turrets and casemates. Earthern parapets and traverses, sometimes arranged with a core of concrete or rubble masonry to gain resistance to shot, are generally used for barbette batteries.

It is not generally considered possible to bar the progress of an armored fleet by the mere fire of the battery; some obstruction sufficient to arrest the ships within effective range of the guns is necessary. The kind of obstruction now relied upon is the torpedo in the form of a submarine mine, and except in special cases exploded by electric currents, which are so managed that the operator on shore can either ignite the mine under the ship's bottom or allow the ship to explode it by contact. In deep channels the submarine mines are buoyant; in comparatively shallow waters they are placed upon the bottom; the object in both cases being to touch or nearly approach the hull of the vessel. Submarine mines are not accessaries of the defense, but are essential features, whenever they can be applied. Bomb-proof operating rooms and

tunnels for the conveyance into the water of the electric cables are necessary parts of the system, and must be constructed in advance of the occasion for their use.

Special batteries of guns are instituted for the defense of the lines of mines against the attempt of unarmored or light armored boats to countermine or grapple for their attachments. These guns may be arranged with electrical connections so as to be discharged by the very attempt to meddle with the system. The smooth-bores of 8 and 10 inch calibers and the 8-inch converted rifles already in service will be needed to defend the mines against attempts of this nature; but it would be advisable to replace them in part with 5, 6, and 8-inch rifles. The guns thus displaced, together with the 15-inch smooth-bores now on hand, will be usefully employed in the defense of places of minor importance.

When practicable every mine-field should be commanded by electric search-lights, so that the enemy's attempts at night to tamper with the mines may be detected and rendered abortive.

Movable torpedoes operated from shore stations are still in the experimental stage; and no definite recommendation except for experimental trials could now be made. The successful operation of these torpedoes would add another element to the defense of the mines.

Torpedo boats would prove of great use in defeating attempts against the mines, made either with small or large vessels.

Heavy batteries and submarine mines are correlative terms of a good defense from the shore. Without powerful guns in the defense the armored ships of the enemy would proceed deliberately to the removal of the mines, either ignoring or silencing the fire of the works, and without the aid of the mines the enemy's vessels could not generally be prevented from running past the batteries.

To serve the mines, operating casemates, cable-tunnels, and electric search-lights are necessary. An instructed *personnel* is required for the placing into position and the service of submarine mines, owing to the technical nature of the operations. The battalion of engineers instructed in this duty is now restricted to 400 men. So soon as proper accommodations can be arranged for them at the post of Willets Point, the number should be increased to the limit allowed by law.

Rapid-firing guns also would be of use against the torpedo boats and the unarmored portions of ships, and a certain number should be provided in the defense. Machine guns for flanking defenses and sweeping mine-fields, for repelling assaults upon the works, and for other purposes, will be necessary.

The material of which the powerful guns needed in the fixed and floating defenses are to be constructed, is also a proper subject of discussion if it is intended to secure strength with a minimum of weight which the Board deems of much moment, in view of the complication, weight, and additional cost of the gun-carriages arising from the increased dimensions of the gun, and of other vital considerations.

Cast iron as material has been advocated on account of supposed cheapness and facility of manufacture, but the sole method of arriving at a sound conclusion in this respect is a careful analysis. A comparison has been made between breech-loading cast-iron rifles and Krupp's steel rifles, which by no means sustains the claims

either of superior economy or facility of manufacture for a cast-iron gun of power equal to one made of steel.* On the other hand the difference of weight against the cast iron appears to be 66 per cent. of the weight of the steel gun, a defect which would greatly interfere with facility of maneuver and rapidity of fire. It would be singular if, after waiting for so many years with the alleged intention of profiting by the experience of nations foremost in the manufacture of heavy ordnance, we should begin the long-neglected defense of the country with accepting a material for guns which, after having been tried by leading European nations, has been deliberately rejected in favor of steel. The Board emphatically recommends steel.

The great improvement in the quality of steel and in the manufacture of slow-burning powders, with the resulting increase in the length of bore and weight of the

* The following comparison of the weight and power of cast-iron and steel guns is based on the actual performance of the United States experimental 12-inch breech-loading rifle, cast iron, and the Krupp 12-inch breech-loading rifle, steel, the brown German prismatic powder being used with both guns.

Results somewhat more favorable, it is true, have been obtained from the 12-inch breech-loading rifle, cast iron, with Dupont's brown priasmtic powder; but it is fair to assume that results equally favorable would attend the employment of Dupont's powder with the Krupp 12-inch rifle—consequently the results obtained with the German powder, which has been actually tested with both guns, will furnish quite as good a basis for comparison.

By virtue of certain well-established principles in gunnery, relative to the similitude of guns, with similarity of loading, it is easy to deduce the caliber and weight of a piece, of either of the above types, which shall possess a given power, or which shall have the *same* power, for instance, as a piece of the other type. In this way we may reduce our data to the same absolute standard, and thus give the analysis a strictly *quantitive* character.

Data.	Powder.	Charge.	Projectile.	Velocity.	Pressure.	Energy at muzzle.
		Pounds.	*Pounds.*	*Feet.*	*Tons.*	*Foot-tons.*
United States 12-inch B. L. rifle, cast iron; weight, 54 tons; length of bore, 28 calibers	German brown	265	800	1,709	14.0	16,197
Krupp's 12-inch B. L. rifle, steel; weight, 48 tons; length of bore, 32 calibers	do	357	1,003	1,857	17.3	23,907

From the above it appears that the Krupp 12-inch rifle imparts to its projectile 7,710 foot-tons more energy than the 12-inch cast-iron rifle; and it is this energy—*smashing effect*—which is assumed to be the measure of effect against hard armor, as steel, with which all new types of armored ships are now plated, and is therefore the material against which guns for coast defense will in future be required to contend.

The price of the experimental 12-inch rifle, cast iron, was about $540 per ton; that of the Krupp 12-inch rifle was probably not more than $1,120 per ton, making the total cost of the first $29,160, and of the other about $53,760. The relative weight of piece to energy of projectile is, for the 12-inch cast-iron gun, 33 tons, and for the Krupp 12-inch gun 20.1 tons, or less than two-thirds that of the cast-iron gun. The energy per pound of powder is 61 foot-tons for the 12-inch cast-iron gun, and 67.2 foot-tons for the Krupp 12-inch gun.

Let us now compare these results by a common standard. Under the limitations imposed in connection with the principle of the similitude of guns, &c., we assume that the weight of the piece, of the charge, of the projectile, and the energy of the projectile are directly proportional to the cube of the caliber.

(1) What will be the caliber, weight of piece, of charge, and of projectile of a cast-iron gun that shall possess the same energy as the Krupp 12-inch rifle, viz, 23,907 foot-tons?

From our premises, given and assumed, we deduce the following, viz:

Caliber.	Length of bore.	Weight of piece.	Charge.	Projectile.	Velocity.	Pressure.
Inches.	*Calibers.*	*Tons.*	*Pounds.*	*Pounds.*	*Feet.*	*Tons.*
13.7	28	79.7	391	1,180	1,709	14

As has been stated, the price of the 12-inch cast-iron gun was about $540 per ton, which would give as the cost of this 80-ton gun, $43,092. But in the manufacture of a second gun similar to the 12-inch cast-iron rifle, three

charge, has already within a few years past led to a marked increase in the velocity and energy of the projectile, without impressing an undue strain upon the walls of the gun, and it is this condition of the art which has set aside that which at one time promised to be a useful invention—guns manufactured on the multi-charge principle, such as the "Haskell" and "Ripley." The Board cannot recommend the manufacture or purchase of either of these guns. From information which appears to have been carefully compiled and laid before the Board, the Haskell multi-charge gun would much exceed in weight and cost a single-charge gun of the same power.

The nature of the projectile to be used will vary with the target. Common shell of steel or iron carrying large bursting charges will be effective against the unarmored parts of vessels. Against wrought-iron plates the projectile may be made of chilled cast-iron; but hard armor exacts for its penetration or destruction the use of steel, forged and tempered. In connection with steel-armor-piercing projectiles, reference may be made to a system of manufacture by which steel shot are rolled of superior quality and true to gauge. So far the process has been applied only to small calibers, but if successful for larger ones, a needed supply will be obtained at a small cost.

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separate castings proved failures. The failure of the first ought to have been foreseen, and could have been prevented. The failure of the second occurred by successive transverse fractures while in the lathe; and the third was ruptured longitudinally while still in the casting-pit. The two latter failures, even now, are not clearly understood, and their tendency is to largely increase the uncertainty and risk attendant upon the manufacture of such large castings, and thus to enhance their cost. It is highly probable, therefore, that the cost per ton will materially increase for a cast-iron gun of 80 tons weight, and it may not be far out of the way, perhaps, to assume the cost for such a gun at $600 per ton, or, say, a total cost of about $48,000. To this sum must be added the increased cost for the very much larger and heavier carriage required for the service of such a piece, which will, it is quite safe to say, bring up the aggregate cost fully to that paid for the Krupp 12-inch rifle, with its mounting.

But it is important to bear in mind that, as yet, we have no evidence touching the endurance of cast-iron guns, the experimental 12-inch cast-iron gun having been fired, up to the present date, only about thirty rounds. And, further, we have no guarantee whatever that a satisfactory endurance with one cast-iron gun will prove a safe criterion in respect to the endurance of the next one that may be tried, so many and so great are the uncertainties attendant upon the production of sound, strong castings of such large mass.

Let us now solve the inverse problem, viz:

(2) What will be the caliber, weight of piece, of charge, and projectile of a *steel* gun of the Krupp type that shall have the same energy as the 12-inch cast-iron gun, viz, 16,197 foot-tons?

In this case we deduce the following:

Caliber.	Length of bore.	Weight of piece.	Charge.	Projectile.	Velocity.	Pressure.
Inches.	*Calibers.*	*Tons.*	*Pounds.*	*Pounds.*	*Feet.*	*Tons.*
10.5	32	32½	242	677	1,857	17.3

At $1,120 per ton, this gun would cost $36,400. But the cost of Krupp's 12-inch rifle of 37 tons, as given on a price-list of 1882, was only $1,012 per ton, so that we may assume from $32,500 to $36,400 as the cost of the 10½-inch gun of 32½ tons weight.

These figures, as compared with the price—$29,160—paid for the 12-inch cast-iron gun, are quite favorable to the steel gun; the difference in cost is not great, particularly when it is remembered that *cheapness* is the chief merit claimed for cast iron, as an offset to its manifold imperfections.

It will be observed that the same energy is here obtained with a gun of about one-half the weight of the cast-iron gun, and which therefore possesses great advantage with respect to facility of handling, and permits besides of a considerable saving in weight of charge and projectile.

Referring again to the failure of the three 12-inch gun-castings, the limit of weight for cast-iron guns would seem to be practically reached with a 12-inch rifle of 54 tons weight; and their production in quantity, even of that caliber and weight, will unquestionably seriously delay the development of the steel industry of this country, to which alone we must have recourse for guns of the highest power, and indeed for guns of all calibers and of whatever power, where strength, lightness, and facility of handling are *desiderata*.

In conclusion, it may be stated that the prices paid for Armstrong's steel guns, so far as they have been made public, are less than the figures assumed above as the cost of guns of Krupp manufacture.

Among the most important means of conducting an active defense of the coast is the torpedo boat, which, although recently developed, has received the sanction of the nations of Europe, each one of which now possesses a large number of these vessels. Their use will be quite general, first, in disturbing blockades and preventing these from being made close, as no fleet would like to lie *over night* within striking distance of a station of these boats; second, in attacking an enemy's ship enveloped in fog or smoke; third, in relieving a vessel pursued by the enemy; fourth, in defending the mines by night and day against attempts at countermining, and in many other ways not necessary to recapitulate.

Impressed with the utility of this mode of defense, the Board has recommended the construction of 150 of these boats, and desires further to say that in its opinion this service requires a special corps of officers and men from the Navy trained to their use.

The self-moving torpedo, one example being the "Whitehead," would be the main reliance. The spar torpedo might be used from launches, but as in general this service would be of the nature of a forlorn hope, and liable to fail of success, its principal recommendation would be ease of improvising and the absence of other suitable means to the end.

Submarine boats have not passed the experimental stage, and the Board has at present no recommendation to make in their regard.

Aerial torpedoes with large charges of high explosives projected in curved or vertical fire, while they demand consideration, have not yet arrived at a stage of development demanding practical discussion.

LIST OF PORTS, WITH DESCRIPTION OF FORTIFICATIONS AND OTHER DEFENSES, WITH REFERENCE TO ARMAMENT, MINES, TORPEDOES, ETC.

(1) *New York.*—This important port must be fortified at both entrances in the most thorough manner. *Fortifications:* Turrets, armored casemates, barbette batteries, mortar batteries. Submarine mines will form a part of the defense. Eighteen torpedo-boats are recommended for service in this harbor.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
16-inch.....	110-ton guns	18	B. L. R.
14-inch.....	80-ton guns	2	B. L. R.
12-inch.....	50-ton guns	40	B. L. R.
10-inch.....	27-ton guns	20	B. L. R.
8-inch.....	13-ton guns	15	B. L. R.
12-inch.....	Mortars.....	144	Rifled.

(2) *San Francisco.*—This is a most exposed point, and, owing to the width across the channel, difficult to be defended by guns from the shore. Floating batteries are consequently required to be added to the defense. *Fortifications:* Turrets, barbette batteries, mortar batteries. Submarine mines will form a part of the defense. Eighteen torpedo boats are recommended for service at this harbor. Three floating batteries are recommended for the defense in addition to the land batteries.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
16-inch.....	110-ton guns	10	B. L. R.
14-inch.....	80-ton guns	4	B. L. R.
12-inch.....	50-ton guns	20	B. L. R.
10-inch.....	27-ton guns	71	B. L. R.
8-inch.....	13-ton guns	5	B. L. R.
12-inch.....	Mortars	128	Rifled.

(3) *Boston.*—This port has a wide opening to seaward, with three approaches, and consequently requires extensive works of defense. *Fortifications:* Turrets, armored casemates, barbette batteries, mortar batteries. Submarine mines will form a part of the defense. Eighteen torpedo-boats are recommended for service here.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
16-inch.....	110-ton guns	8	B. L. R.
12-inch	50-ton guns	10	B. L. R.
10-inch.....	27-ton guns	15	B. L. R.
8-inch	13-ton guns	10	B. L. R.
12-inch.....	Mortars	132	Rifled.

(4) *The Lake ports.*—The situation being peculiar, an explanation becomes necessary. The treaty of 1817 between the United States and England limited each party to an insignificant naval force upon the Lakes.* At that time the country on both sides was undeveloped; with the exception of Detroit there was nothing perhaps deserving the name of town upon the Upper Lakes. Everything has changed; large cities as centers of commerce now dot the coasts of the lake, and the wealth and property liable to capture and destruction are enormous in amount. In the mean while our neighbors over the line have surmounted the rapids of the Saint Lawrence and the Falls of Niagara by canals which, in their present condition, permit the passage of boats of 9 feet draught, and when the improvements shall have been finished will have a depth of 14 feet. The present draught will admit many gunboats now in the possession of Great Britain, and when the depth of water is increased, armored vessels from the other side of the Atlantic may float in the waters of Lake Erie. A state of

* *Arrangement between the United States and Great Britain, made by Richard Rush, esq., acting as Secretary of the Department of State, and Charles Bagot, His Britannic Majesty's envoy extraordinary, &c., concluded April* 28, 1817.

The naval force to be maintained upon the American lakes by His Majesty and the Government of the United States shall henceforth be confined to the following vessels on each side, that is:

On Lake Ontario, to one vessel, not exceeding one hundred tons burden, and armed with one 18-pound cannon.

On the upper lakes, to two vessels, not exceeding like burden each, and armed with like force.

On the waters of Lake Champlain, to one vessel, not exceeding like burden, and armed with like force.

All other armed vessels on these lakes shall be forthwith dismantled, and no other vessels of war shall be then built or armed.

If either party should hereafter be desirous of annulling this stipulation, and should give notice to that effect to the other party, it shall cease to be binding after the expiration of six months from the date of such notice.

The naval force so to be limited shall be restricted to such services as will in no respect interfere with the proper duties of the armed vessels of the other party.

war, therefore, with that power, would at this time, unless something be done to avert the consequences, involve the lake cities in frightful losses or even destruction. These cities, being upon the shore, could not by land forts be protected from bombardment. Fort Wayne, on the Detroit River, if supplied with suitable armament well placed, could, with the assistance of submarine mines and torpedoes, prohibit a passage into Lake Huron. The canal at the Sault Ste. Marie would also demand a fort to protect it from destruction.

Our commerce on the Upper Lakes is much more extensive than that of Canada, and doubtless many of the steamers might at a pinch be converted into light-armed naval vessels. But to do this, with any prospect of anticipating the arrival of British gunboats after the declaration of war, the vessels should be inspected, beginning now, and the inspections continued, so that a perfect knowledge might be obtained of the number and description of all that might be fit for the service designed, and plans of their modification to receive the guns be made and kept, so that when the vessels are wanted there should be no unnecessary delay in preparing them for service. It is needless to state that the guns and other necessary material should also be provided, ready for use at a moment's warning.

Upon Lake Ontario the Canadian commerce is superior to ours. Some protection, however, would be needed here, which, imperfect as it is, might serve a good purpose It is proposed to keep in one of the interior lakes of New York vessels armed with light guns and furnished with self-moving torpedoes, to be sent when needed, by canal, into Lake Ontario. Some might be sent to Buffalo for service in the Upper Lakes. A port of refuge against the superior naval force of England should be provided in the lower part of Lake Ontario.

The fort at Rouse's Point is sufficient, with the addition of a few 8-inch rifles, to secure Lake Champlain from an inroad.

It may be observed that one or more fortifications on the Saint Lawrence River would be required, which, in the event of hostilities, could at once protect our frontier and command the water approaches to the Lakes. They would be more reliable than an improvised fleet upon Lake Erie, though they could not wholly take its place.

Proposed armament.

Locality.	Caliber.	Kind.	Number.	Remarks.
Fort Wayne	10-inch	27-ton guns	3	B. L. R.
	8-inch	13-ton guns	3	B. L. R.
	6-inch	5-ton guns	4	B. L. R.
	10-inch	Mortars	8	Rifled.
Proposed fort on Saint Lawrence River	12-inch	50-ton guns	2	B. L. R.
	10-inch	27-ton guns	6	B. L. R.
	10-inch	Mortars	8	Rifled.
Fort Montgomery, Rouse's Point	8-inch	13-ton guns	4	B. L. R.
	10-inch	Mortars	8	Rifled.

(5) *Hampton Roads.—Fortifications:* Turrets, armored casemates, barbette batteries, mortar batteries. Submarine mines will form a part of the defense. Eighteen torpedo boats are recommended for the service here and in Chesapeake Bay.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
16-inch.....	110-ton guns	4	B. L. R.
12-inch.....	50-ton guns	10	B. L. R.
10-inch.....	27-ton guns	20	B. L. R.
12-inch	Mortars	16	Rifled.

(6) *New Orleans.*—It being impossible to place submarine mines in the trunk of the river below the city, but only in the Passes, and as no land batteries could be built there on account of the want of a foundation, it is recommended that the defense of the Passes be confided to two floating batteries, submarine mines, and other torpedoes. Twelve torpedo-boats are recommended for this station.

Proposed armament for land batteries above the Head of the Passes.

Caliber.	Kind.	Number.	Remarks.
12-inch.....	50-ton guns	20	B. L. R.
8-inch.....	13-ton guns	10	B. L. R.

(7) *Philadelphia.—Fortifications:* Armored casemates, barbette batteries, mortar batteries. Submarine mines will form a part of the defense. Six torpedo-boats are recommended for service at this place.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
12-inch.....	50-ton guns	10	B. L. R.
10-inch.....	27-ton guns	5	B. L. R.
8-inch.....	13-ton guns	5	B. L. R.
12-inch.....	Mortars	16	Rifled.

(8) *Washington.—Fortifications:* Barbette batteries. Submarine mines will form a part of the defense.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
12-inch.....	50-ton guns	7	B. L. R.
10-inch.....	27-ton guns	6	B. L. R.

(9) *Baltimore.—Fortifications:* Armored casemates, barbette batteries, mortar batteries. Submarine mines will form a part of the defense.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
12-inch.....	50-ton guns	5	B. L. R.
10-inch.....	27-ton guns	5	B. L. R.
8-inch.....	13-ton guns	5	B. L. R.
12-inch.....	Mortars	16	Rifled.

(10) *Portland, Me.—Fortifications:* Barbette batteries, mortar batteries. Submarine mines will form a part of the defense. Six torpedo-boats are recommended for service here.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
12-inch.....	50-ton guns	20	B. L. R.
10-inch.....	27-ton guns	10	B. L. R.
8-inch.....	13-ton guns	10	B. L. R.
12-inch.....	Mortars	48	Rifled.

(11) *Rhode Island ports*—Entrance to Narragansett Bay. *Fortifications:* Turret, barbette batteries, mortar batteries. Submarine mines will form a part of the defense. Six torpedo-boats are recommended for service in this bay.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
16-inch.....	110-ton guns	2	B. L. R.
12-inch.....	50-ton guns	10	B. L. R.
10-inch.....	27-ton guns	10	B. L. R.
12-inch	Mortars	48	Rifled.

(12) *Key West.*—This port is in the direct route of the Gulf commerce. *Fortifications:* Turret, barbette batteries, mortar batteries. Submarine mines will form a part of the defense. Six torpedo-boats are recommended for service.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
16-inch.....	110-ton guns	2	B. L. R.
12-inch.....	50-ton guns	10	B. L. R.
12-inch.....	Mortars	32	Rifled.

(13) *Charleston, S. C.*—It is necessary to provide fortified ports of refuge along the extended coast line of North and South Carolina and Georgia. *Fortifications:* Barbette batteries, mortar batteries. Submarine mines will form a part of the defense. Six torpedo-boats are recommended for service along the coast.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
12-inch.....	50-ton guns	8	B. L. R.
10-inch.....	27-ton guns	4	B. L. R.
12-inch.....	Mortars	16	Rifled.

(14) *Mobile.*—A place of commercial importance and the outlet of the products of Alabama. *Fortifications:* Barbette batteries, mortar batteries. Submarine mines will form a part of the defense.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
12-inch.....	50-ton guns	12	B. L. R.
8-inch.....	13-ton guns	10	B. L. R.
12-inch.....	Mortars	16	Rifled.

(15) *New London.—Fortifications:* Barbette batteries. Submarine mines will form a part of the defense. Eighteen torpedo-boats are recommended for service.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
12-inch.....	50-ton guns	4	B. L. R.
10-inch.....	27-ton guns	4	B. L. R.

(16) *Savannah.—Fortifications:* Armored casemates, barbette batteries. Submarine mines will form a part of the defense.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
12-inch.....	50-ton guns	8	B. L. R.
10-inch.....	27-ton guns	6	B. L. R.
8-inch.....	13-ton guns	4	B. L. R.
12-inch.....	Mortars	16	Rifled.

(17) *Galveston.*—This place cannot be defended by landworks against an active bombardment, and fortifications are proposed simply to prevent an enemy's vessel from entering the harbor. *Fortifications:* Barbette batteries, mortar batteries. Submarine mines will form a part of the defense. One of the light-draught monitors would be useful to assist in the defense.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
8-inch.....	13-ton guns	8	B. L. R.
12-inch.....	Mortars	16	Rifled.

(18) *Portland, Oreg.*, at mouth of the Columbia River and above.—*Fortifications:* Barbette batteries, mortar batteries. Submarine mines will form a part of the defense. Eighteen torpedo-boats are recommended for service along the Northern Pacific coast.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
10-inch.....	27-ton guns	12	B. L. R.
8-inch.....	13-ton guns	7	B. L. R.
12-inch.....	Mortars	32	Rifled.

(19) *Pensacola.—Fortifications:* Barbette batteries. Submarine mines will form a part of the defense.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
12-inch.....	50-ton guns.....	2	B. L. R.
10-inch.....	27-ton guns.....	4	B. L. R.

(20) *Wilmington, N. C., and mouth of Cape Fear River.—Fortifications:* Armored casemates, barbette batteries. Submarine mines will form a part of the defense.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
12-inch.....	50-ton guns.....	4	B. L. R.
10-inch.....	27-ton guns.....	5	B. L. R.

(21) *San Diego, Cal.—Fortifications:* Barbette batteries. Submarine mines will form a part of the defense.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
10-inch.....	27-ton guns.....	4	B. L. R.

(22.) *Portsmouth, N. H.—Fortifications*: Barbette batteries. Submarine mines will form a part of the defense.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
12-inch.....	50-ton guns.....	4	B. L. R.
10-inch.....	27-ton guns.....	4	B. L. R.

(23) *Defenses of Cumberland Sound at Fort Clinch.*—This is the most southern harbor of importance on the Atlantic coast. *Fortifications:* Barbette batteries. Submarine mines will form a part of the defense.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
12-inch.....	50-ton guns.....	2	B. L. R.
10-inch.....	27-ton guns.....	2	B. L. R.

(24) *Defenses of ports on the Kennebec River, Maine, at Fort Popham.—Fortifications:* Barbette batteries. Submarine mines will form a part of the defense.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
10-inch.....	27-ton guns.....	8	B. L. R.

(25) *New Bedford, Mass.—Fortifications:* Barbette batteries, mortar batteries. Submarine mines will form a part of the defense.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
8-inch	13-ton guns	3	B. L. R.
12-inch	Mortars	16	Rifled.

(26) *Defenses of ports on the Penobscot River, Maine, at Fort Knox.—Fortifications:* Barbette batteries. Submarine mines will form a part of the defense.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
10-inch	27-ton guns	3	B. L. R.

(27) *New Haven, Conn.—Fortifications:* Barbette batteries, mortar batteries. Submarine mines will form a part of the defense.

Proposed armament.

Caliber.	Kind.	Number.	Remarks.
8-inch	13-ton guns	3	B. L. R.
12-inch	Mortars	8	Rifled.

GUNS ON HAND.

The sea-coast guns now available for use are:

Kind of gun.	Number.	Description.
Rodman guns—smooth bore	2	20 inch.
do	308	15 inch.
do	998	10 inch.
do	210	8 inch.
Parrott guns—rifled	38	*300 pounders.
do	81	*200 pounders.
do	173	*100 pounders.
Converted rifles	†210	8 inch.

* Of doubtful strength.
† 160 on hand, and 50 to be delivered under contract.

Some of these smooth-bore and rifled guns will be used to defend the torpedo lines, and the remainder may be distributed to existing forts and batteries, as well as to ports not named in the foregoing report. It is probable that with the addition of two modern rifles of minor calibers at such places, with little additional expense for constructions, the existing defenses will suffice to secure ports of minor importance from marauding attacks. For these reasons the smooth-bore guns enumerated above should not be sold. The provisions of the law did not require the Board to make a report including all places where defenses might at some future time be required, and the Board has therefore confined itself to a general mention of this part of the coast defense.

It is not necessary or expected that the order of urgency should be strictly followed in the lower part of the list of ports prepared by the Board, for it is likely that pending the period at which these ports will be reached in their order, changes impossible to foresee may occur in their relative importance and urgency, and such changes may also modify the extent of the defenses and armament proposed in particular cases, so that what may be taken from one will be added to another.

Attention is invited to the following tabular statements based upon careful study of the local requirements of each port. It has not been deemed expedient, for prudential and other reasons, to make public the actual sites of the batteries:

(1) Estimate for land defenses, exclusive of armament.
(2) Estimate for armament and mountings.
(3) Estimate for floating batteries, including armament.
(4) Estimate for submarine mines and their adjuncts.
(5) Estimate for torpedo-boats.

ESTIMATE FOR LAND DEFENSES EXCLUSIVE OF ARMAMENT.

[NOTE.—The following estimates are based upon the use of rolled iron for armor plates, because the penetrations into that material have been the most studied, but in view of the substitution of steel, in whole or in part, for rolled iron the cost for equivalent protection would probably be the same.]

Locality.	Number of guns and mortars wanted.	IRON, WROUGHT AND CAST.				Cost of masonry and earth.	Total cost.
		Armor, wrought.		Structural metal.			
		Weight.	Cost.	Weight.	Cost.		
		Tons.		*Tons.*			
New York City, including both entrances.	9 2-gun turrets	13,635	$4,050,000	2,925	$450,000	$1,800,000	$6,300,000
	30 in casemates	13,050	3,900,000	1,950	390,000	1,200,000	5,490,000
	8 on lifts				160,000	640,000	800,000
	39 disappearing and non-disappearing					1,560,000	1,560,000
	144 mortars					288,000	288,000
	Total	26,685	7,950,000	4,875	1,000,000	5,488,000	14,438,000
San Francisco	5 2-gun turrets	7,575	2,250,000	1,625	250,000	1,000,000	3,500,000
	10 on lifts				200,000	800,000	1,000,000
	90 disappearing and non-disappearing					3,600,000	3,600,000
	128 mortars					256,000	256,000
	Total	7,575	2,250,000	1,625	450,000	5,656,000	8,356,000
Boston	4 2-gun turrets	6,060	1,800,000	1,300	200,000	800,000	2,800,000
	10 in casemates	4,350	1,300,000	650	130,000	400,000	1,830,000
	15 disappearing and non-disappearing					600,000	600,000
	10 barbette					150,000	150,000
	132 mortars					264,000	264,000
	Total	10,410	3,100,000	1,950	330,000	2,214,000	5,644,000
The Lake ports, including Fort Wayne and Saint Lawrence River.	5 in casemates	2,175	650,000	325	65,000	200,000	915,000
	3 on lifts				60,000	240,000	300,000
	14 disappearing and non-disappearing					560,000	560,000
	24 mortars					48,000	48,000
	Land defenses					600,000	600,000
	Total	2,175	650,000	325	125,000	1,648,000	2,423,000
Hampton Roads, Va.	2 2-gun turrets	3,030	900,000	650	100,000	400,000	1,400,000
	10 in casemates	4,350	1,300,000	650	130,000	400,000	1,830,000
	20 disappearing and non-disappearing					800,000	800,000
	16 mortars					32,000	32,000
	Total	7,380	2,200,000	1,300	230,000	1,632,000	4,062,000

ESTIMATE FOR LAND DEFENSES EXCLUSIVE OF ARMAMENT—continued.

Locality.	Number of guns and mortars wanted.	IRON, WROUGHT AND CAST.				Cost of masonry and earth.	Total cost.
		Armor, wrought.		Structural metal.			
		Weight.	Cost.	Weight.	Cost.		
		Tons.		*Tons.*			
New Orleans	30 disappearing and non-disappearing					$1,200,000	$1,200,000
Philadelphia	10 in casemates	4,350	$1,300,000	650	$130,000	400,000	1,830,000
	10 disappearing and non-disappearing					400,000	400,000
	16 mortars					32,000	32,000
	Total	4,350	1,300,000	650	130,000	832,000	2,262,000
Washington	13 disappearing					520,000	520,000
Baltimore	5 in casemates	2,175	650,000	325	65,000	200,000	915,000
	10 disappearing and non-disappearing					400,000	400,000
	16 mortars					32,000	32,000
	Total	2,175	650,000	325	65,000	632,000	1,347,000
Portland, Me.	10 on lifts				200,000	800,000	1,000,000
	30 disappearing and non-disappearing					1,200,000	1,200,000
	48 mortars					96,000	96,000
	Total				200,000	2,096,000	2,296,000
Narragansett Bay, both entrances.	1 2-gun turret	1,515	450,000	325	50,000	200,000	700,000
	5 on lifts				100,000	400,000	500,000
	15 disappearing and non-disappearing					600,000	600,000
	48 mortars					96,000	96,000
	Total	1,515	450,000	325	150,000	1,296,000	1,896,000
	Total of above 11 ports	62,265	18,550,000	11,375	2,680,000	23,214,000	44,444,000
Key West, Fla	1 2-gun turret	1,515	450,000	325	50,000	200,000	700,000
	5 on lifts				100,000	400,000	500,000
	5 disappearing and non-disappearing					200,000	200,000
	32 mortars					64,000	64,000
	Repairs					200,000	200,000
	Total	1,515	450,000	325	150,000	1,064,000	1,664,000
Charleston, S. C.	4 on lifts				80,000	320,000	400,000
	8 disappearing and non-disappearing					320,000	320,000
	16 mortars					32,000	32,000
	Repairs					200,000	200,000
	Total				80,000	872,000	952,000
Mobile, Ala.	4 on lifts				80,000	320,000	400,000
	18 disappearing and non-disappearing					720,000	720,000
	16 mortars					32,000	32,000
	Repairs					300,000	300,000
	Total				80,000	1,372,000	1,452,000
New London, Conn	4 on lifts				80,000	320,000	400,000
	4 disappearing and non-disappearing					160,000	160,000
	Repairs					100,000	100,000
	Total				80,000	580,000	660,000
Savannah, Ga	5 in casemates	2,175	650,000	325	65,000	200,000	915,000
	8 disappearing and non-disappearing					320,000	320,000
	16 mortars					32,000	32,000
	Repairs					100,000	100,000
	Total	2,175	650,000	325	65,000	652,000	1,367,000

ESTIMATE FOR LAND DEFENSES EXCLUSIVE OF ARMAMENT—continued.

Locality.	Number of guns and mortars wanted.	IRON, WROUGHT AND CAST.				Cost of masonry and earth.	Total cost.
		Armor, wrought.		Structural metal.			
		Weight.	Cost.	Weight.	Cost.		
		Tons.		*Tons.*			
Galveston, Tex	8 disappearing and non-disappearing					$320,000	$320,000
	16 mortars					32,000	32,000
	Keeps					200,000	200,000
	Total					552,000	552,000
Portland, Oreg	12 disappearing and non-disappearing					480,000	480,000
	7 barbette					105,000	105,000
	32 mortars					64,000	64,000
	Keeps					200,000	200,000
	Total					849,000	849,000
Pensacola, Fla	2 on lifts				$40,000	160,000	200,000
	4 disappearing and non-disappearing					160,000	160,000
	Repairs					200,000	200,000
	Total				40,000	520,000	560,000
Wilmington, N. C	5 in casemates	2,175	$650,000	325	65,000	200,000	915,000
	2 on lifts				40 000	160,000	200,000
	2 disappearing and non-disappearing					80,000	80,000
	Keeps					200,000	200,000
	Total	2,175	650,000	325	105,000	640,000	1,395,000
San Diego, Cal	4 disappearing and non-disappearing					160,000	160,000
	Keeps					100,000	100,000
	Total					260,000	260,000
Portsmouth, N. H	8 disappearing and non-disappearing					320,000	320,000
	Keeps					100,000	100,000
	Total					420,000	420,000
Defenses of Cumberland Sound, at Fort Clinch.	2 on lifts				40,000	160,000	200,000
	2 disappearing and non-disappearing					80,000	80,000
	Total				40,000	240,000	280,000
Defenses of ports on the Kennebec River, Me., at Fort Popham.	3 disappearing and non-disappearing					120,000	120,000
New Bedford, Mass	3 disappearing and non-disappearing					120,000	120,000
	16 mortars					32,000	32,000
	Total					152,000	152,000
Defenses of ports on the Penobscot River, Me., at Fort Knox.	3 disappearing and non-disappearing					120,000	120,000
New Haven, Conn	3 disappearing and non-disappearing					120,000	120,000
	8 mortars					16,000	16,000
	Keeps					100,000	100,000
	Total					236,000	236,000
	Grand total	68,130	20,300,000	12,350	3,320,000	31,863,000	55,483,000

ESTIMATE FOR ARMAMENT AND MOUNTINGS.

	Locality.	Guns.						Mortars.		Cost of guns and mortars.	Cost of carriages.	Total cost.
		16-inch.	14-inch.	12-inch.	10-inch.	8-inch.	6-inch.	12-inch.	10-inch.			
1	New York City:											
	Willets Point	6	.....	10	5	5	.....	48	.....	$1,744,000	$580,000	$2,324,000
	Narrows, Sandy Hook, Coney Island	12	2	30	15	10	.....	96	.....	4,283,000	1,412,000	5,695,000
2	San Francisco	10	4	20	71	5	.....	128	.....	5,426,000	1,787,000	7,213,000
3	Boston	8	.....	10	15	10	.....	132	.....	2,971,000	970,000	3,941,000
4	Lake ports:											
	Fort Wayne	.....	.....	.....	3	3	4	.....	8	188,000	59,800	247,800
	Saint Lawrence River	.....	.....	2	6	.....	.....	.....	8	310,000	100,000	410,000
	Fort Montgomery, Rouse's Point	.....	.....	.....	.....	4	.....	.....	8	100,000	30,000	130,000
5	Hampton Roads	4	.....	10	20	.....	.....	16	.....	1,608,000	534,000	1,142,000
6	New Orleans (Mississippi River)	.....	.....	20	.....	10	.....	.....	.....	1,130,000	380,000	1,510,000
7	Philadelphia	.....	.....	10	5	5	.....	16	.....	828,000	274,000	1,102,000
8	Washington (Potomac River)	.....	.....	7	6	.....	.....	.....	.....	512,000	171,000	683,000
9	Baltimore	.....	.....	5	5	5	.....	16	.....	578,000	190,000	768,000
10	Portland, Me	.....	.....	20	10	10	.....	48	.....	1,784,000	587,000	2,371,000
11	Rhode Island ports (Narragansett Bay)	2	.....	10	10	.....	.....	48	.....	1,374,000	450,000	1,824,000
12	Key West	2	.....	10	.....	.....	.....	32	.....	976,000	320,000	1,296,000
13	Charleston, S. C	.....	.....	8	4	.....	.....	16	.....	636,000	210,000	846,000
14	Mobile	.....	.....	12	.....	10	.....	16	.....	858,000	284,000	1,142,000
15	New London	.....	.....	4	4	.....	.....	.....	.....	308,000	103,000	411,000
16	Savannah	.....	.....	8	6	4	.....	16	.....	492,000	162,000	654,000
17	Galveston	.....	.....	.....	.....	8	.....	16	.....	232,000	75,000	307,000
18	Portland, Oreg. (mouth Columbia River)	.....	.....	.....	12	7	.....	32	.....	671,000	219,000	890,000
19	Pensacola	.....	.....	2	4	.....	.....	.....	.....	208,000	71,000	279,000
20	Wilmington, N. C	.....	.....	4	5	.....	.....	.....	.....	335,000	112,000	447,000
21	San Diego, Cal	.....	.....	.....	4	.....	.....	.....	.....	108,000	36,000	144,000
22	Portsmouth, N. H	.....	.....	4	4	.....	.....	.....	.....	308,000	103,000	411,000
23	Defenses of Cumberland Sound at Fort Clinch	.....	.....	2	2	.....	.....	.....	.....	154,000	52,000	206,000
24	Defenses of ports on the Kennebec River Me., at Fort Popham	.....	.....	.....	3	.....	.....	.....	.....	81,000	27,000	108,000
25	New Bedford, Mass	.....	.....	.....	.....	3	.....	16	.....	167,000	53,000	220,000
26	Defenses of ports on the Penobscot River, Me., at Fort Knox	.....	.....	.....	3	.....	.....	.....	.....	81,000	27,000	108,000
27	New Haven, Conn	.....	.....	.....	.....	3	.....	8	.....	103,000	33,000	136,000
	Total	44	6	203	222	102	4	700	24	28,554,000	9,411,800	37,965,000

ESTIMATE FOR FLOATING BATTERIES, INCLUDING ARMAMENT.

Locality.	Number of batteries.	Number of guns each.			Total number of guns.			Cost of ships and armament.
		16-inch.	14-inch.	10-inch.	16-inch.	14-inch.	10-inch.	
1. New Orleans	2	2	.....	1	4	.....	2	$8,150,000 00
2. San Francisco	3	.....	2	2	.....	6	6	10,725,000 00
Total	5	2	2	3	4	6	8	18,875,000 00

ESTIMATE FOR SUBMARINE MINES AND THEIR ADJUNCTS.

Seaport.	Submarine mines.			Operating rooms, &c.		Electric lights, complete.		Grand total.
	In store.	Number needed.	Cost.	Number.	Cost.	Number of projectors.	Cost.	
New York	560	690	$241,500	5	$50,000	20	$120,000	$411,500
San Francisco	461	589	206,150	7	120,000	28	168,000	494,150
Boston	185	215	75,250	5	50,000	20	120,000	245,250
Lake ports	.....	200	70,000	4	40,000	16	96,000	206,000
Hampton Roads	.....	400	140,000	2	20,000	8	48,000	208,000
Mississippi River	.....	150	52,500	2	30,000	8	48,000	130,500
Philadelphia	215	85	12,250	3	30,000	12	72,000	114,250
Washington	.....	150	52,500	2	20,000	8	48,000	120,500
Baltimore	.....	100	35,000	1	10,000	4	24,000	69,000
Portland	.....	350	122,500	4	60,000	16	96,000	278,500
Narragansett Bay, both entrances	.....	300	105,000	2	20,000	8	48,000	173,000
Key West	.....	150	52,500	1	10,000	4	24,000	86,500
Charleston	.....	150	52,500	1	10,000	4	24,000	86,500
Mobile	.....	300	105,000	1	15,000	4	24,000	144,000
New London	.....	150	52,500	3	45,000	12	72,000	169,500
Savannah	.....	300	105,000	3	45,000	12	72,000	222,000
Galveston	.....	150	52,500	1	15,000	4	24,000	91,500
Pensacola	.....	200	70,000	1	15,000	4	24,000	109,000
Portsmouth	.....	161	56,350	2	20,000	8	48,000	134,350
Ten minor ports defended by existing works	.....	.....	.....	.....	.....	.....	.....	840,000
Total	1,421	4,740	1,659,000	50	635,000	200	1,200,000	4,334,000

ESTIMATE FOR TORPEDO BOATS.

Locality.	Torpedo boats.		Torpedo gunboats.	Cost.
	No. of groups.	No. of boats.	Number.	
1. New York	3	18	.....	$1,080,000
2. San Francisco	3	18	.....	1,080,000
3. Boston	3	18	.....	1,080,000
4. The Lake ports	.....	.....	12	720,000
5. Hampton Roads	3	18	.....	1,080,000
6. New Orleans	2	12	.....	720,000
7. Philadelphia	1	6	.....	360,000
8. Portland, Me	1	6	.....	360,000
9. Rhode Island ports in Narragansett Bay	1	6	.....	360,000
10. Key West	1	6	.....	360,000
11. Charleston, S. C	1	6	.....	360,000
12. New London	3	18	.....	1,080,000
13. Portland, Oreg	3	18	.....	1,080,000
Total	25	150	12	9,720,000

PRACTICAL MEASURES FOR OBTAINING THE APPLIANCES FOR DEFENSE.

There is no difficulty in procuring from the resources of our own country all the appliances for defense except guns and steel armor.

There are two, and only two, methods by which modern guns and armor can be procured. These are, first, by direct purchase from the immense establishments now existing abroad, or, second, by domestic manufacture.

The workshops of Europe, with all their facilities for turning out this material, are now fully occupied by the demands upon them. They are, in fact, expanding every day. Experience has shown that the few experimental orders already given from this country are filled only after long delays; and it is impossible to estimate the time required for the delivery of the large quantities we urgently need. Moreover, war would at once put a stop to such importations and leave us helpless in the emergency. The disbursement abroad of the large sums involved in these purchases would not be profitable to this country. On the other hand, if spent here, they would encourage home industries, promote the national wealth, and render our defenses independent of other countries. For these reasons the Board cannot too strongly condemn a resort to foreign purchases.

What, then, are the facilities for procuring these supplies in our own country?

None but the best crucible or open-hearth steel, possessing certain well-known physical qualities, is suitable for gun manufacture; and the ingots must be forged by hydraulic presses or under hammers of power far exceeding any here existing. The Board is entirely in favor of presses.

After a careful study of the extensive plant required for the production of steel-gun forgings and armor-plates of sizes, thicknesses, and qualities suitable for such manufacture, and after an inspection of our principal works and foundries, the conclusion is forced upon the Board that the necessary facilities for the production of such large masses of steel, and the machines for fashioning this metal into guns and armor, are not now to be found in this country.

At the Midvale Steel Works, Philadelphia, at the Cambria Steel Works, Johnstown, and elsewhere, plant is available for 6-inch and probably 8-inch forgings of a quality not surpassed by the best made abroad. But the 8-inch gun is the very smallest recommended for extensive use in our forts; so that, practically, this plant would have to be made anew to meet the demand for larger calibers.

It is clear that to effect the object of the act of Congress under which this Board was appointed, the manufacture and tempering of steel in enormous masses must be provided for by Congressional legislation.

The same can be said of the large and extensive workshops, and tools for machining the steel.

The Board, basing its estimates upon the report of the Gun Foundry Board, considered that, to accomplish the work and accomplish it well, the plant necessary for making the tempered steel for the parts of guns up to the largest calibers will cost about $850,000, and that the plant for fabricating such guns will cost about $900,000,—this sum being exclusive of expenditures necessary to arm the Navy.

The vital question then arises, in what manner can such steel works and machine shops be best created?

It cannot be expected that even the richest and most flourishing of our steel works, with millions of capital to uphold it, will venture such an amount of money in plant, merely in the doubtful hope that the Government may give a contract sufficiently large to save it from loss.

Business men know that the action of one Congress does not control the action of subsequent Congresses, and that, unless the appropriation is made permanent, running through several years, pledging the United States to such an expenditure, there is no certainty as to the future, and the risk is far greater than the chances of profit.

After due consideration of the subject, this Board indorses the conclusions of the Gun-Foundry Board contained in the supplementary report of December 20, 1884, as follows, viz:

The question whether the fabrication can be better and more economically performed in Government establishments, or by private contract, or by a combined system, has been carefully considered, and the Board has been unable to discover any reason to modify the unanimous opinion expressed in its report of February 16, 1884, that "it is more judicious to establish gun factories;" that there should be "two gun factories under the control of the Government; and that the Army and Navy should be provided with separate establishments."

The requirements of the two services in this respect are sufficiently distinct to justify two separate establishments, which, in the interests of the national defense, would be fully occupied for many years to come—probably long enough to exhaust their capacity for good work.

An appropriation, therefore, of $1,000,000 for a factory is recommended and should be made at once, as it would require about two years to erect and equip it. The money required for machining and completing the guns at the factory could be appropriated in the following year, when the forgings would be about ready for delivery.

Again this Board quotes from and indorses the report of the Gun-Foundry Board:

The Board repeats its unanimous opinion "that the steel manufacturers should be called upon to provide the material" and recommends—

(1) An appropriation of not less than $15,000,000—one-half for the Army and one-half for the Navy—to remain available until expended; provided, however, that none of the money so appropriated shall be expended except in payment for steel accepted and delivered.

(2) Proposals to be issued by the War and Navy Departments for bids for the supply of the steel required by each, rough-bored, rough turned, tempered, and conforming to specifications. Said proposals shall divide the steel required into two lots. Each lot shall include all the parts for one half of the number of guns of each caliber. Each bid must include all of a lot or lots. Each bidder shall agree to deliver yearly a specified quantity of each caliber, the time of delivery of the smaller calibers to commence at the expiration of not more than eighteen months, and that of the largest calibers at the expiration of not more than three years from the date of acceptance of the contract. Each bidder shall specify the price of the parts for each of the several calibers. This price may be modified by the Government in equity, according to the current rates of labor and material.

(3) Bids to be considered must be made by responsible parties, each of which shall certify and guarantee to erect in the United States a suitable plant capable of making all the steel required, and of finishing it in accordance with the contract.

From personal intercourse with prominent steel makers in the United States, the Board is in a position to assert that proposals issued on the above basis will be responded to, but that it will be necessary to appropriate the entire amount recommended, in order to induce *responsible* steel manufacturers to erect and complete the plants to produce the steel for the guns needed for national defense.

The above proposition contains only such a guarantee as would be required by business men embarking in a new and expensive undertaking.

In the matter of procuring the needful supply of armor, the Board does not consider that specific recommendations are required. Armor plates of moderate dimensions can now be fabricated in this country, and the demand for steel armor for naval purposes, joined to that for guns, and perhaps for turrets, will, it is believed, afford all needful encouragement to induce our steel manufacturers to procure the plant.

RECAPITULATION OF ESTIMATES.

The following consolidated estimate presents the cost of defending our entire sea-coast and lake frontier upon the plan recommended by the Board; and, also, that for defending the eleven ports where the expenditure is most urgently required. The cost of machine guns, ammunition, transportation, and for proving guns and armor is not included, because somewhat indefinite in character, although not very great. The appropriations will be asked for as needed by the proper Departments.

CONSOLIDATED ESTIMATE.

	Port.	Land defenses.			Armament.		Floating batteries and their armament.	Submarine mines and their adjuncts.	Torpedo-boats.	Total.
		Masonry and earth-work.	Armor.	Structural metal.	Guns and mortars.	Carriages.				
1	New York	$5,488,000	$7,950,000	$1,000,000	$6,027,000	$1,992,000	.....	$411,500	$1,080,000	$23,948,500
2	San Francisco	5,656,000	2,250,000	450,000	5,426,000	1,787,000	$10,725,000	494,150	1,080,000	27,868,150
3	Boston	2,214,000	3,100,000	330,000	2,971,000	970,000	.....	245,250	1,080,000	10,910,250
4	The Lake ports	1,648,000	650,000	125,000	598,000	189,800	.....	206,000	*720,000	4,136,800
5	Hampton Roads	1,632,000	2,200,000	230,000	1,608,000	534,000	.....	208,000	1,080,000	7,492,000
6	New Orleans	1,200,000	.....	.....	1,130,000	380,000	8,150,000	130,500	720,000	11,710,500
7	Philadelphia	832,000	1,300,000	130,000	828,000	274,000	.....	114,250	360,000	3,838,250
8	Washington	520,000	.....	.....	512,000	171,000	.....	120,500	.....	1,323,500
9	Baltimore	632,000	650,000	65,000	578,000	190,000	.....	69,000	.....	2,184,000
10	Portland, Me	2,096,000	.....	200,000	1,784,000	587,000	.....	278,500	360,000	5,305,500
11	Narragansett Bay	1,296,000	450,000	150,000	1,374,000	450,000	.....	173,000	360,000	4,253,000
	Total of above 11 ports	23,214,000	18,550,000	2,680,000	22,836,000	7,524,800	18,875,000	2,450,650	6,840,000	102,970,450
12	Key West	1,064,000	450,000	150,000	976,000	320,000	.....	86,500	360,000	3,406,500
13	Charleston	872,000	.....	80,000	636,000	210,000	.....	86,500	360,000	2,244,500
14	Mobile	1,372,000	.....	80,000	858,000	284,000	.....	144,000	.....	2,738,000
15	New London	580,000	.....	80,000	308,000	103,000	.....	169,500	1,080,000	2,320,500
16	Savannah	652,000	650,000	65,000	492,000	162,000	.....	222,000	.....	2,243,000
17	Galveston	552,000	.....	.....	232,000	75,000	.....	91,500	.....	950,500
18	Portland, Oreg	849,000	.....	.....	671,000	219,000	.....	100,000	1,080,000	2,919,000
19	Pensacola	520,000	.....	40,000	208,000	71,000	.....	109,000	.....	948,000
20	Wilmington, N. C	640,000	650,000	105,000	335,000	112,000	.....	100,000	.....	1,942,000
21	San Diego	260,000	.....	.....	108,000	36,000	.....	100,000	.....	504,000
22	Portsmouth, N. H	420,000	.....	.....	308,000	103,000	.....	134,350	.....	965,350
23	Cumberland Sound	240,000	.....	40,000	154,000	52,000	.....	150,000	.....	636,000
24	Kennebec River	120,000	.....	.....	81,000	27,000	.....	70,000	.....	298,000
25	New Bedford	152,000	.....	.....	167,000	53,000	.....	150,000	.....	522,000
26	Penobscot River	120,000	.....	.....	81,000	27,000	.....	70,000	.....	298,000
27	New Haven	236,000	.....	.....	103,000	33,000	.....	100,000	.....	472,000
	Grand total of 27 ports	31,863,000	20,300,000	3,320,000	28,554,000	9,411,800	18,875,000	4,334,000	9,720,000	126,377,800

* Torpedo gun-boats.

A comparison can now be made of the estimates for modern works with those made in 1840, when the old system of coast defense had received considerable development and was being pressed toward completion. The population of the country at

that time was 17,000,000, and the estimate of cost, including the amounts already expended, was $57,131,541, being at the rate of $3.35 per head.

The population in 1880 was 50,000,000, and the estimate for the coast defense is $126,377,800, at the rate of $2.52 per head.

The valuation of property in 1880 was $43,642,000,000; that of 1840 was about $4,000,000,000, and it is to be seen that the ratio of the estimate for defenses to the wealth of the country at the present time exhibits a still more favorable comparison.

In 1840 the cost of the line-of-battle ship, then representing the most formidable means of attack against coast defenses, was about $550,000, and the cost of the corresponding war ship of the present day is about $5,000,000. While the ships have increased in cost nine-fold, the estimate of the defenses to resist these has increased only between two and three-fold.

Certain portions only of the whole amount above indicated as necessary are needed at once, viz:

A. An appropriation for gun steel sufficient to induce contracting steel works to prepare for and begin the manufacture of steel forgings for guns of all calibers, $8,000,000.

B. An appropriation for a gun factory with plant sufficient to machine, assemble, and finish the guns, $1,000,000.

C. An appropriation to inaugurate the building of masonry foundations, engine-rooms, shell-rooms, magazines, &c., necessary to the reception of the armor, guns, &c., $4,000,000 for the first year and $2,000,000 annually thereafter until completed.

D. An appropriation for armor and structural metal, $2,000,000 annually until completed.

E. An appropriation for gun-carriages, $1,000,000 annually until completed.

F. An appropriation for the building of floating batteries, the type to be selected by a joint board of Army and Navy officers, $3,000,000 for the first year and $2,000,000 annually until completed.

G. An appropriation for submarine mines and their adjuncts, $1,000,000 for the first year and $500,000 annually thereafter until completed.

H. An appropriation for building torpedo-boats, $1,500,000 annually until all are built.

Summing up these recommendations, the Board presents the following project for annual appropriations:

APPROPRIATIONS RECOMMENDED.

Purpose.	Appropriation for first year.	Future annual appropriations until work is completed.
A. Gun metal	$8,000,000	.....
B. Gun factory	1,000,000	.....
C. Masonry, &c	4,000,000	$2,000,000
D. Armor, &c	2,000,000	2,000,000
E. Gun-carriages	1,000,000	1,000,000
F. Floating batteries	3,000,000	2,000,000
G. Submarine mines, &c	1,000,000	500,000
H. Torpedo-boats	1,500,000	1,500,000
Totals	21,500,000	9,000,000

After mature consideration, and with all the information before it, the Board is of opinion, and recommends that the above-named amounts should be appropriated by Congress without delay, for the purposes mentioned, and it further states that nothing less will suffice even for a beginning.

In order to enable the Department to carry out this large project without delay, it is suggested that the present laws requiring advertising for bids and making contracts should be materially modified. Contracts should be made to continue for a series of years, and smaller purchases should be made in open market. Under the present laws it is impossible at times to carry on the work intrusted to the Department, and not infrequently unnecessary expenditures arise without accruing advantages.

WM. C. ENDICOTT,
Secretary of War, President of the Board.
S. V. BENÉT,
Brigadier-General, Chief of Ordnance, U. S. Army.
JOHN NEWTON,
Brigadier-General, Chief of Engineers, U. S. Army.
HENRY L. ABBOT,
Lieutenant-Colonel of Engineers, U. S. Army.
CHAS. S. SMITH,
Captain of Ordnance, U. S. Army.
W. T. SAMPSON,
Commander, U. S. Navy.
C. F. GOODRICH,
Commander, U. S. Navy.
JOS. MORGAN, JR.
ERASTUS CORNING.

EDW'D MAGUIRE,
Captain of Engineers, U. S. Army,
Secretary of the Board.

WASHINGTON, D. C., *January* 16, 1886.

REPORT OF THE COMMITTEE TO COLLECT INFORMATION AND REPORT UPON THE VARIOUS KINDS OF ARMOR, THE PENETRATION AND EFFECTS OF SHOT UPON ARMOR AND EARTH, AND GUNS AND THEIR RANGES.

COMMITTEE No. 1.

Brig. Gen. S. V. Benét, Chief of Ordnance, U. S. A., Chairman.
Brig. Gen. John Newton, Chief of Engineers, U. S. A.
Lieut. Col. Henry L. Abbot, Corps of Engineers, U. S. A.
Commander Casper F. Goodrich, U. S. Navy.
Capt. Charles S. Smith, Ordnance Department, U. S. A.

NEW YORK CITY, *July* 13, 1885.

Hon. WILLIAM C. ENDICOTT,
Secretary of War, President of the Board:

SIR: The committee appointed at the last meeting of the Board to collect information and report upon the various kinds of armor, the penetration and effect of shot upon armor and earth, and guns and their ranges, has the honor to present the following report:

Four kinds of armor are now recognized—rolled iron, chilled cast iron, compound, and forged and tempered steel.

Rolled-iron armor was first introduced, and has been far more exhaustively studied than any other variety. It was used during the civil war, and plates 12 feet long, 4 feet wide, and 12 inches thick were manufactured in this country and tested at Fort Monroe as long ago as 1868.

Chilled cast iron, manufactured by Gruson in Germany, has received favor upon the continent of Europe, and has been partially introduced in various defensive works both on the sea-coast and for land fortifications. It endures the fire of small guns extremely well, but has not been tested with calibers above 12 inches or with energies exceeding about 15,000 foot-tons.

Compound armor is of comparatively recent origin, and is of two types—a backing of rolled iron faced with Bessemer steel (Wilson's patent), and a backing of rolled iron faced with a plate of hard rolled steel cemented by a layer of Bessemer steel (Ellis' patent). These varieties are manufactured both in England and France, of dimensions equal in weight to 50 tons. Experiments have failed to indicate any well-marked difference between them in resisting power.

Forged-steel armor, tempered in oil, is a recent product of the great works at Creusot. It is fabricated by the open-hearth process, and is forged under the 100-ton hammer.

The latest experiments indicate the superiority of these forged-steel plates; but as it may be expedient and even necessary in harbors of minor importance to use armor not offering the highest resistance to penetration, the committee is not prepared to exclude compound or other varieties from the defenses of the country. The problem is local and should be treated locally.

With regard to the actual penetration thus far accomplished in armor, earth, and masonry, the dimensions and power of modern guns and their observed and computed ranges, the committee would refer to the appended tables, which have been prepared to exhibit the latest results achieved. To include the earlier experiments would extend them beyond reasonable limits. The information has been collected with no little labor by Commander Goodrich and Captain Smith, and it is suggested that the tables and other data accompanying them be printed for the use of the Board.

It will be seen from these tables that while the utility and necessity of armor for fortifications has been fully established by experiments abroad, there are yet remaining certain details which can only be determined by independent trials conducted against plates manufactured in this country. Such experiments need not in the least delay the construction of the fortifications and their armament, because very large and costly foundations for the gun emplacements, as well as magazines, shell-rooms, engine-rooms, and other constructions proof against shot and shell, must be prepared in advance of the iron-works. Years must elapse before they can be in readiness.

In any form of armored fortifications provision should be made for increasing the thickness of the plating, and perhaps for varying its external composition, to meet the probable increase in the power of artillery. In land constructions where weight is of secondary importance this can always be done.

As to guns the committee believes that nothing less than the most approved types for each caliber are admissible, and that for the most important sites not less than 60,000 foot-tons of muzzle energy will be imperatively necessary. These guns should be made of steel and manufactured in this country. They should possess the merits of simplicity, strength, and a construction approved by experience.

The limited experiments in the manufacture of gun-steel in this country satisfies the committee that liberal appropriations will enable the private manufacturers to supply ingots of all sizes equal to any produced in Europe.

The subject of gun carriages has received great attention at home and abroad, and the problem has been practically solved for the various conditions of their employment. While objections can be urged against most if not all of the patterns, yet the subject has reached a state of development which warrants the conclusion that when the fortifications are completed guns of any caliber will be suitably and effectively mounted.

The nature of the projectile to be used varies with that of the target. Common shell of steel or iron carrying large bursting charges will be effective against the unarmored parts of vessels. Against wrought-iron plates the projectile may be made of chilled

cast iron; but hard armor exacts for its penetration or destruction the use of steel, forged and tempered.

Against unarmored ships, and the unarmored portions of iron-clads, the value of rapid-firing guns, comparatively large in caliber, can hardly be overestimated. At present the 6-pounder Hotchkiss leads in the competition, but it would be rash to conclude that much larger projectiles will not shortly be fired from non-recoil guns. Emplacements for such weapons must be included in any complete system of fortifications.

The increasing length of modern guns has brought about the manufacture abroad of what is known as brown prismatic or cocoa powder. Its combustion produces a moderate but sustained pressure in the bore until the projectile has left the gun, thus giving great muzzle energy without dangerous stresses. The committee is glad to be able to state that our own makers of powder have produced a grade that in a 6-inch breech-loading rifle yields a greater velocity with a less strain upon the gun than accompanies the use of the original German article.

Respectfully submitted.

S. V. BENÉT,
Brigadier-General, Chief of Ordnance,
Chairman Committee.

REPORT OF SUBCOMMITTEE ON ARMOR, GUNS AND THEIR RANGES, ETC.

To Brig. Gen. S. V. BENÉT:

SIR: In compiling the data relative to the resistance of armor to penetration, the subcommittee charged with this duty encountered at the outset the necessity of exercising a selection to prevent its tables from becoming overburdened with facts that have but a historical value. It determined, therefore, to present as accurate a statement as was obtainable of the present condition of the conflict between guns and armor, as well as of the competition between the various kinds of plates themselves. As this competition has narrowed itself down to two types, all steel and steel-faced-iron (compound) armor, the subcommittee has chiefly gathered together the results of the principal published trials of these two varieties. In order that a fair estimate may be had of the worth of wrought iron and chilled cast iron, it has included in its tables a few specimen trials of the former either directly comparable with those of steel and compound, or instructive through the magnitude or peculiarity of the targets, together with as complete an account of the tests of the latter as can be found. Finally are presented certain records of firing against butts of earth, sand, or concrete, and a table of computed penetrations in earth, granite, &c.

The inevitable displacement of wrought iron by more resisting materials necessitates a recasting of the mathematical expressions defining the effect on a given plate produced by a given projectile moving at a given rate, a recasting not yet satisfactorily accomplished.* The calculated penetration in wrought iron, while given for the sake of comparison and to complete the elements of fire, is, however, no longer a criterion of the result actually achieved. In its stead appear a multitude of effects, racking and piercing, so involved as to render their reduction to a common standard almost impracticable. For the present all that can be predicated of the tabulated experiments is that they show clearly that a certain thickness of plate of whatever nature will be wrecked by an impact of a certain number of foot-tons. Here, again, enter as conditions which may completely overthrow all speculation, the material and mode of fabrication of the projectile, weight of the plate, and the character of the backing. The data are yet too limited to furnish the relative values which should be assigned to these factors. It may, however, be stated—

1. That steel armor promises to replace both iron and compound.
2. That projectiles designed for the piercing of hard armor must be made of steel.
3. That the larger the plate the better it is able to absorb the energy of impact without injury to itself.
4. That the backing must be as rigid as possible.

* A rule of thumb adopted provisionally by certain authorities on the subject prescribes the subtraction of from 25 to 30 per cent. from the penetration in iron to obtain that in compound or steel armor.

ARMOR.

Experiments at Manchester in 1878 and at Spezia in 1882 and 1884 point to the value of all-steel plates. The Amager trials of last year are deficient in their yield of results through the inferior backing afforded the Schneider plate, and it is hardly fair to quote them against the use of steel. The problem which presents itself for solution to would-be makers of armor in the United States is whether it is advisable to experiment with a view to perfecting the manufacture of all-steel or of compound plates. Since either course is open to them at the outset it would seem incumbent to indicate which of the two is considered most promising. The Subcommittee on Guns and Armor can hardly do better than to confirm the finding of the Board of Engineers for Fortifications, &c., of which Colonel Tower was president, as contained in its report dated January 9, 1883, "that hammered steel in the late Spezia trials proved superior to any other material hitherto tested for armor plates." Subsequent experiments within the past year more than bear out the accuracy of this conclusion. In suggesting steel as the preferable material for plates, the subcommittee believes that it is only following the drift of manufacturing progress which tends so clearly towards the substitution of that metal for iron in all important engineering works; but it is not, of course, to be regarded as barring the way to the development, if desired by any manufacturer, of the fabrication of compound armor.

It is proper to state that Schneider, of Creusot, is said to unite in one plate of steel a hard face and a soft back—in other words, to gain for all-steel the advantages claimed for the compound system; and to oil-temper the face.

PROJECTILES.

The preference of steel for projectiles against hard armor scarcely needs proof, so generally is it conceded. For illustration, however, it may be well to refer to a 9-inch Whitworth steel projectile which passed, practically undamaged, through 18 inches of iron, and with enough remaining velocity to pierce a solid backing and bury itself 17 feet deep in sand; or to the Spezia trials of 1879 against Terre Noire cast-steel plates, where a Whitworth projectile got, undeformed, through 27.56 inches of metal, while a chilled-iron shell possessing greater energy not only failed to penetrate but broke into a number of pieces. In these trials a steel shell made by Armstrong, having somewhat less energy, was kept out by the plate, but it wrecked the latter completely. At Shoeburyness in 1877 a steel shell from the Woolwich 9-inch M. L. rifle succeeded in completely penetrating a 10-inch compound plate, while a chilled projectile possessing greater energy got but 5.5 inches into a 10.6-inch compound plate in 1880. Even after making due allowance for the probable improvement in the manufacture of compound plates in the interim, and for the difference in thickness, the comparison of these results is instructive.

It must be remembered that mere penetration is not all that is to be sought. If a shell can get entirely through the plate or nearly so before the explosion of its bursting charge takes place, the damage to the guns, carriages, and gun detachments behind it is vastly increased. Where the armor and the gun are nearly matched, this result appears possible only when the projectile is hard enough to secure perforation and tough enough

to hold together. To state the question in these terms is to limit the choice of material for this purpose to steel, forged or compressed and tempered.

It is not out of place at this point to emphasize the necessity of experience in the forging and treating of steel projectiles. The methods adopted by such successful makers as Whitworth and Krupp are trade secrets. They must be worked out afresh by our own manufacturers, who can only expect to reach a satisfactory end after many failures. For this reason their early attention should be called to the matter and their co-operation requested.

SIZE OF PLATE.

The behavior of a compound plate under fire is supposed to be as follows: The hard face tends to break up the projectile; that is, to make it expend its energy on itself rather than upon the plate. After this first instant the shock is distributed throughout the entire plate by means of the tough and fibrous back. Unless the gun is so superior to the armor as to render the penetration unquestionable, it is easily seen that the plate is the more severely taxed the smaller it is. For this reason the quantity "energy per ton of plate" affords a ready means of approximately comparing the strain thrown on different plates of the same thickness. It would seem as if the 11-ton 11-inch Ellis plate profited by its size, so much severer were the tests it withstood than those of its companion weighing two tons less. It must, however, be evident that there exists a limit beyond which the increased size of the plate ceases to diminish by distribution the local strain of impact. This limit is not definitely determined for any given thickness of armor, but it is safe to urge upon makers the desirability of rolling their plates as large as is compatible with excellence of manufacture.

BACKING.

Too much stress can hardly be laid upon the necessity of solid backing. Before the trial of August, 1883, where the 81-ton gun failed to send its 1,700-pound projectile through a 12-inch compound plate bolted against a solid granite butt, no one would have ventured to predict the actual result. While the behavior of the plate would doubtless have been somewhat different had the shell been made of steel, this instance of the safe absorption of over 2,800 foot-tons of energy per ton of plate imposes upon the engineer a careful adjustment of his construction in order to hold the plate well up to its work. It is proper to state in this connection that the chief constructor of the British navy has recently expressed himself as convinced that a reduction of 4 inches of plating, or from 18 to 14, will prove a material gain if the weight thus saved in armor be used to secure more rigid backing

To present a tabular statement of the impact energy which a given thickness of plate can safely receive, is impossible with the incomplete data at hand. An inspection of the accompanying schedule of trials will show that, speaking in general terms of forged steel and compound armor, a 5-inch plate will be severely strained by an impact of 1,200 foot-tons; that a plate 9 inches in thickness may be expected to give way under a blow of about 4,000 foot-tons; that an 11-inch plate can be struck several times with a blow of 4,000 foot-tons, but will not keep out a shot having an

energy of 11,000 foot-tons; that 8,000 foot-tons stored up in a single shot should not seriously affect a 12-inch plate as ordinarily mounted; that a 14¼-inch plate receiving 11,800 foot-tons is about at its limit of resistance; that a 16-inch plate may or may not keep out 12,600 foot-tons, according to circumstances; that an impact of over 15,000 foot-tons will seriously tax a 19-inch plate if of indifferent quality or if not well backed, while 20,000 foot-tons may be expected to destroy any such plate not of exceptional quality; and that a 22-inch plate is completely overmatched by a single impact of 30,000 foot-tons.

Finally, in deciding upon the thickness of armor needed in our fortifications, it must not be forgotten that the construction of a 156-ton gun is under consideration in England which is to have a total energy of 97,000 foot-tons, with a calculated penetration in wrought-iron of 42.7 inches at 1,000 yards, while 110-ton guns are now under fabrication for ships already afloat which will have a maximum energy of 61,200 foot-tons and a corresponding penetration in iron of 35.0 inches. It is true that the former gun is designed for coast defense, but progress in such matters is so rapid that it would be unwise to assume that similar weapons of offense will not be afloat before our new fortifications are completed. In regard to the range of guns the subcommittee finds that its present maximum is stated as about 13 miles. The greatest practicable range of any gun is, however, controlled by the nature of its mounting. The carriages of to-day rarely permit more than 20° of elevation above the normal horizontal plane. On ship-board the gun might possibly, under certain circumstances, be given a few degrees more of elevation through listing or heeling the vessel, but even this procedure would hardly bring a target 10 miles distant within reach of the projectile. What guns in the near future may be able to do is a matter of speculation, nevertheless it is prudent to overestimate rather than underrate this development.

The subcommittee cannot pass lightly over the merits of Gruson's chilled armor. It regrets that the tests of this system have not been conducted on a sufficiently extensive scale, both as to number of fires and weight of projectile, to establish its superiority or inferiority to compound and steel plates. At present it can only affirm that the behavior of the latter is fairly well known under all circumstances, while what the former might do under, for instance, a Spezia ordeal can only be conjectured. It is significant that Italy and Germany, two very progressive military powers, have made large contracts with the patentee for the supply of his turrets, but the duty of the subcommittee seems to be clear to base its judgment upon ascertained facts. The excessive weight of the Gruson turret, the thinness about the casemate embrasures, the inconvenience if not impossibility of adding to its thickness in case of need, the inadvisability of either confining our armor supply to a foreign manufacturer or of having to work out his methods here experimentally, combine with its as yet undetermined value under heavy fire to remove it from the scope of serious consideration.

Respectfully submitted.

C. F. GOODRICH,
Commander, U. S. Navy, Chairman of Subcommittee.
CHAS. S. SMITH,
Captain, Ordnance Department, U. S. Army.

TABLE I.—PRINCIPAL DIMENSIONS, WEIGHTS,

KRUPP'S SHIP AND

Nature of cannon.	Caliber.	Weight.	Total length.	Length of bore.	Powder. Kind.	Powder. Weight.	Powder. Density of loading.	Projectile. Length.	Projectile. Weight.	Ratio of weight of charge to weight of projectile.	Ratio of weight of projectile to weight of piece.	Initial velocity.	Pressure.	At muzzle. Total energy (smashing effect).	At muzzle. Penetration in iron.
Steel cannon.	*Inches.*	*Tons.*	*Feet.*	*Calibers*		*Pounds*		*Calibers*	*Pounds*			*Feet.*	*Tons.*	*Foot-tons.*	*Inches.*
40cm gun, 35 cals. length (under fabrication for the Italian navy).	15.75	108 *119	45.9	32 *31.7	....	750 *615	.....	3.5	2,240 *1,632	2.99 2.65	108 163.33	1,835 *2,017	17.0	52287 *46061	33.0 31.0
40cm gun, 25 cals. length	15.75	71	32.8	21.78	Black prismatic, 4 cartridges.	462	.871	2.8	1,762	3.81	90.24	1,095	17.2	35174	27.0
35.5cm gun, 35 cals. length (projected).	13.98	75.3	40.7	31.7	.....	520 †462	....	....	1,560 †1,155	3.00 2.50	108.12 146.03	1,835 †1,985	17.0	36459 †31626	29.25 27.25
35.5cm gun, 30 cals. length	13.98	57.5	34.9	26.8	Brown	312	.898	3.1	1,155	3.70	111.52	1,724	14.4	23850	23.75
35.5cm gun, 25 cals. length	13.98	51.1	29.1	21.8	Brown	297	.855	2.8 3.1	1,155	3.89	99.10	1,617	17.4	20979	22.25
30.5cm gun, 35 cals. length	12.00	48	35.1	32	Brown Black	357 323	.917 .833	3.5 3.5	1,003 1,003	2.81 3.11	107.19 107.19	1,857 1,720	17.3 18.0	23905 20582	25.75
30.5cm gun, 25 cals. length	12.00	37	25	22	Brown	264	.847	3.5	1,003	3.80	82.63	1,536	15.8	16403	21.5
28cm gun, 35 cals. length	11.024	37	32.2	32	Brown	253	.853	3.5	759	3.00	109.19	1,837	17.0	17808	23.0
28cm gun, 30 cals. length	11.024	27.3	27.6	27	Brown	185	.867	3.5	759	4.10	80.57	1,627	15.7	13969	20.5
26cm gun, 35 cals. length	10.24	27.2	29.9	32	Brown	183	.855	3.5 4.5	614	3.36	99.23	1,768	16.3	13339	20.75
24cm gun, 35 cals. length	9.45	20.5	27.6	32	Brown	150	.901	3.5–4.5	476	3.17	96.47	1,791	15.4	10617	19.5
24cm gun, 30 cals. length	9.45	18.9	23.6	27	Brown	150	.901	.....	476	3.17	88.94	1,726	15.3	9849	18.5
21cm gun, 35 cals. length	8.24	13.3	24	32	Brown	99	.901	3.5–4.5	310	3.17	96.10	1,808	15.9	7036	17.0
21cm gun, 30 cals. length	8.24	12.3	20.6	27	Brown	99	.894	3.5 4.5	307	3.14	89.75	1,702	15.6	6205	15.75
17cm gun, 30 cals. length	6.7	7	16.7	27	Brown	57	.909	.....	172	3.02	91.16	1,772	16.8	3742	13.75
17cm gun, 25 cals. length	6.7	6	14	22	.....	51	.833	.....	172	3.37	78.13	1,552	15.3	2871	12.00
15cm gun, 35 cals. length	5.87	4.7	17.1	32	Brown	37.4 39.6	.820	3.5	113 111	3.02 3.80	93.17 94.85	1,773 1,827	14.8 17.5	2464 2571	12.00 12.25
15cm gun, 30 cals. length	5.87	4	14.7	27	Brown	35.2	.901	3.5	113	3.21	79.38	1,723	16.3	2345	11.5
15cm gun, 25 cals. length	5.87	3.9	12.2	22	Brown	33	.847	3.5	113	3.43	77.31	1,585	14.7	1986	10.75
28cm howitzer	11.024	10	10.5	9	Black prismatic, 7 holes.	15.4 19.8 39.6	.293 .365 .730	2.8	475	11.99	47.16	520 673 984	12.9	892 1495 3200	4.25 6.00 9.50

ENGLISH SHIP AND

Armstrong's 110-ton gun, steel for British navy (under fabrication).	16.25	110	43.5	30	C³ Cylindrical	*900	.....	2.8–3.0	*1,800	$\frac{1}{2}$	136.9	*2,020 2,215	..... 15.0	50914 61200	32.0 35.1
Royal Gun Factory 63-ton gun, steel wire (projected).	15.0	63	42.7	32	.....	880	$\frac{25}{1.110}$	.....	1,700	1.93	83.0	2,100	18.0	52000	34.5
Armstrong's 100-ton gun, steel tube and jacket with wrought-iron coils, for Italian navy.	17.0	102	39	26	Fossano Brown Prismatic	772 770	..... .723	....	2,005 1,998 2,005	2.6 2.58	125.1 125.6	1,832 1,840 1,932	16.5 14.6 15.0	46677 46891.8 51900	30.0 30.1 31.7
Royal Gun Factory, 63-ton gun, steel (under fabrication).	13.5	63	38.3	32	C³ Cylindrical	*625	.....	3	*1,250	2.0	112.9	*2,050	.....	36415	29.8
Armstrong's 48-ton gun, steel	13.0	48	.....	35	.....	550	.....	.....	1,100	2.0	97.8	1,900	.....	27535	26.5
Royal Gun Factory, 46 ton gun, steel (under fabrication).	12.0	46	35.1	33	C³ Cylindrical	*450	$\frac{25}{1.110}$	3	*850	$\frac{1}{1.9}$	121.2	*2,100	18.0	25985	26.25
Royal Gun Factory, 43-ton gun, steel tube, wrought-iron coils.	12.0	43	27.5	25	Prismatic	286	.....	2.5	720	2.52	133.8	1,855	17.1	17214	21.8
Armstrong's 40-ton gun	11.0	40	.....	35	.....	350	.....	.....	600	1.71	149.3	2,100	.....	18347	23.6
Armstrong's 21-ton gun, wire-wrapped (experimental).	10.24	21.2	26.4	29.3	Prismatic	260 290	.820 .945	2.8–3.0	502 503	1.93 2.01	94.6 94.4	1,902 2,146	16.8 29.8 20.8 Shot.	12589 16058	20.2 22.8
Royal Gun Factory, 26-ton gun.	10.4	26	24.5	26.5	Prismatic	310	.....	.....	462	1.49	126.1	2,088	16.6	13963	21.15

* Probable.

CHARGES, POWER, RANGE, &c., APPROXIMATELY.

COAST B. L. CANNON.

At muzzle.		At 1,000 yards.		At 2,000 yards.		At 3,500 yards.		Maximum elevation from carriage (fixed platform).	Corresponding range.	Computed ranges at elevation of—				Date of firing.	Remarks.
Energy per pound of powder.	Relative weight of gun to energy of projectile.	Total energy (smashing ef. feet).	Penetration in iron.	Total energy (smashing ef. feet).	Penetration in iron.	Total energy (smashing ef. feet).	Penetration in iron.			10°	15°	20°	25°		
Ft-tons.	*Tons.*	*Foot-tons.*	*Inches.*	*Foot-tons.*	*Inches.*	*Foot-tons.*	*Inches.*	*Degrees.*	*Yards.*	*Yards.*	*Yards.*	*Yards.*	*Yards.*		
69.71 74.89	20.65 25.84	47772 40497	31.5 29.0	43410 35805	30.25 27.5	37644 29507	28.0 25.0	.....	.....	8,830	11,682	13,864	15,587	.....	Proportional to 28cm gun. *Journal R. U. Service Inst'n, No. 126.
76.13	20.18	31151	25.5	27553	24.0	20509	20.75	16	.....	7,409	9,760	11,615	13,123	1882	*Expériences de Tir*, Nos. 37-38, 1882.
70.11 68.45	20.65 23.81	32819 27495	27.75 25.5	29513 23854	26.5 24.75	25114 19210	24.5 21.5	.....	.....	8,586	11,250	13,315	14,924	.....	Proportional to 28cm gun. †*Memorial de Artilleria*, 1880.
76.46	24.03	20620	22.0	17798	20.5	14244	18.5	.....	.....	7,263	9,451	11,177	12,533	1882	*Expériences de Tir*, No. 42, 1882.
70.63	24.36	18109	20.75	15600	19.5	12546	17.5	18	.....	6,598	8,696	10,362	11,676	1882	*Expériences de Tir*, Nos. 33-36, 1882.
67.15	20.08	21253	24.25	18801	22.75	15590	20.75	.....	.....	8,412	10,922	12,866	14,377	1883	*Expériences de Tir*, No. 47, 1883.
62.13	22.56	14447	20.0	12737	18.75	10614	17.25	.....	.....	6,360	8,498	10,216	11,589	1884	*Expériences de Tir*, No. 54, 1884.
70.39	20.78	15569	21.5	13588	20.5	11014	18.25	21	.....	8,031	10,391	12,225	13,655	1884	*Expériences de Tir*, No. 54, 1884.
75.51	19.54	12155	19.25	10547	18.0	8588	16.25	.....	.....	.....	.....	.....	.....	1884	*Expériences de Tir*, No. 54, 1884.
72.89	20.39	11532	19.5	9950	18.0	7940	16.0	.....	.....	7,471	9,698	11,441	12,806	1883	*Expériences de Tir*, No. 50, 1883.
70.78	19.31	9049	18.0	7693	16.5	6003	14.75	.....	.....	7,380	9,542	11,222	12,571	1883	*Expériences de Tir*, No. 50, 1883.
65.66	19.19	8384	17.25	7120	16.0	5566	14.0	20½	.....	.....	.....	.....	.....	1884	*Expériences de Tir*, No. 54, 1884.
71.07	18.90	5844	15.5	4835	14.0	3620	12.25	.....	.....	7,122	9,134	10,779	11,924	1883	*Expériences de Tir*, No. 50, 1883.
62.67	19.82	5106	14.5	4206	13.25	3171	11.5	.....	.....	.....	.....	.....	.....	1882	*Expériences de Tir*, No. 42, 1882.
65.65	18.71	3003	12.5	2387	11.0	1716	8.75	.....	.....	6,538	8,386	9,816	10,930	1884	*Expériences de Tir*, No. 54, 1884.
56.29	20.90	2287	10.75	1833	9.0	1369	7.5	.....	.....	.....	.....	.....	.....	1884	*Expériences de Tir*, No. 54, 1884.
65.88 64.92	19.07 18.28	1901 1977	10.5 10.75	1455 1508	8.5 8.75	1005 1026	6.75 7.0	28	.....	6,386	8,101	9,427	10,417	1882	*Expériences de Tir*, No. 42, 1882.
66.62	17.06	1790	10.0	1371	8.25	956	6.75	.....	.....	.....	.....	.....	.....	1884	*Expériences de Tir*, No. 50, 1884.
60.18	19.64	1506	8.75	1167	7.5	847	6.0	.....	.....	.....	.....	.....	.....	1884	*Expériences de Tir*, No. 50, 1884.
57.92 75.50 80.81	112.11 66.88 31.35	.....	.....	.....	.....	.....	.....	75	.....	.....	.....	.....	.....	1879	*Expériences de Tir*, 1879. Penetration in iron at muzzle, 6 inches; at 2,100 yards, 5 inches.

COAST B. L. CANNON.

56.57 68.0	21.60 17.95	45130.3	30.2	39957.8	28.4	33172.6	25.9	.....	.....	9,396 10,615	12,115 13,419	14,059 15,539	15,618 17,151	.....	Prof. Papers R. E. 1883. Journal R. U. Service Institution, 1884.
59.1	12.15	46576	32.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Office of Naval Intelligence.
60.424	21.865	41334.0	28.3	36566.3	26.6	30292.1	24.2	12	.....	.....	.....	.....	.....	1882	"Engineer," Dec., 1882.
60.898	21.752	41548.0	28.39	36745.0	26.7	30420.0	24.3	.....	.....	8,288	10,773	12,704	14,206	1884	Rothweil-Hamburg Powder Mills.
.....	19.27	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Reports, No. 5, 1884.
58.264	17.300	31390.0	27.7	28623.6	26.4	23808.6	24.1	.....	.....	9,604	12,285	14,326	15,899	.....	Prof. Papers R. E. 1883.
50.07	17.43	24221	24.9	21297	23.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	Office of Naval Intelligence.
57.744	17.702	22566.6	24.4	19622.9	23.3	15840.2	20.9	.....	.....	9,419	11,921	13,823	15,292	.....	Prof. Papers R. E. 1883.
60.189	24.979	14526.3	20.1	12240.0	18.4	9404.8	16.2	.....	.....	.....	.....	.....	.....	1882	Text-book of Gunnery, 1883. Battering charge will be increased to 295 lbs.
52.42	21.80	15545	21.7	13182	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	Office of Naval Intelligence.
48.419	16.840	9451.1	17.6	7886.3	16.1	5994.7	14.0	.....	.....	.....	.....	.....	.....	1885	Getty Board Report, 1882.
55.372	13.202	13477.2	20.9	11664.3	19.5	8702.4	16.8	.....	.....	8,954	11,199	12,951	14,243	1882	
45.041	18.620	11503.1	19.2	9463.6	17.4	6988.5	15.0	.....	.....	.....	.....	.....	.....	1882	Report of Ord. Com., 1883.

Armstrong's 110-ton gun, firing a projectile of 1,800 pounds, with a velocity of 2,215 feet, under an elevation of 41°, has a computed range of 19,768 yards, or 11¼ miles.

TABLE I.—PRINCIPAL DIMENSIONS, WEIGHTS,

ENGLISH SHIP AND

Nature of cannon.	Caliber.	Weight.	Total length.	Length of bore.	Powder. Kind.	Powder. Weight.	Powder. Density of loading.	Projectile. Length.	Projectile. Weight.	Ratio of weight of charge to weight of projectile.	Ratio of weight of projectile to weight of piece.	Initial velocity.	Pressure.	At muzzle. Total energy (smashing effect).	At muzzle. Penetration in iron.
All steel cannon.	*Inches.*	*Tons.*	*Feet.*	*Calibers*		*Pounds.*		*Calibers*	*Pounds.*			*Feet.*	*Tons.*	*Foot-tons.*	*Inches.*
Royal Gun Factory, 26-ton gun (under fabrication).	10.0	26	28.6	32	C² Cylindrical	*300	25/1.10	.....	*500	1.67 / 1 / 1.7	116.0	*2,100	17.5	15285	22.5
Armstrong's 26-ton gun, steel tube, wrought-iron coils.	10.0	26	32	30	Brown / Prismatic	250	.....	.....	452	1.8	122.9	2,113	16.3	13989.5	21.5
Armstrong's 28-ton gun	10.0	28	.....	35	.....	240	.....	.....	450	1.87	139.3	2,120	.....	14023	21.6
Royal Gun Factory, 18-ton gun, steel tube, wrought-iron coils, steel, mark 2.	9.2	18	21.6	26.5	Brown / Prismatic	190 / 165	26.5 / 1.046	.....	320	1.68	126.0	2,105	16.3	9829	18.9
	9.2	18	25.1	31.5	C² Cylindrical	*200	.....	.....	320 / 380	1.94 / 1.9	126.0 / 106.1	2,046 / *2,030	15.4 / 17.0	9285.9 / 10855	18.3 / 19.8
Royal Gun Factory, 9.2, steel tube, wire wrapped (projected).	9.2	18	32.5	40	C² Cylindrical	*330	.....	.....	*380	1.15	106.1	*2,520	.....	16730	24.5
Whitworth's 20-ton gun (steel)	9.0	20	23.8	29.3	.....	194.5 / 197	.....	.....	400 / 405	2.06 / 2.06	112.0 / 110.6	1,898 / 1,997	16.5	9989 / 11196	19.2 / 20.4
Armstrong's 14-ton gun (steel)	8.0	14	.....	*35	.....	120	.....	.....	200	1.66	156.8	3,230	.....	6896	17.0
Royal Gun Factory, 13-ton gun (steel).	8	13	21.3	29.5	Prismatic	100	30.5 / 0.909	.....	210	2.1	138.6	2,030	17.0	5098	15.8
Armstrong's 9-ton gun (steel)	7	9	.....	35	.....	90	.....	.....	145	1.61	138.8	2,240	.....	5045	15.6
Royal Gun Factory, 4-ton gun (steel).	6	3.9	14.2	26	Brown	54	.....	.....	100	1.46	87.4	1,964	15.6	2673.9	12.3
					P²	43	.....	.....	100	2.38	87.4	1,880	13.2	2450	11.7
Armstrong's 3-ton riband gun	6	3	16.7	33.5	Black / Prismatic	60	.....	.....	120	2.0	56.0	2,064	21.3	3545	14.1
Armstrong's 5-ton gun (steel)	6	4.75	.....	35	.....	60	.....	.....	100	1.70	106.4	2,260	.....	3542	14.1
Royal Gun Factory, 2-ton gun (steel).	5	2	11.6	25	.....	25	.....	.....	50	2.0	89.6	1,950	16.0	1317.9	8.9
						16	32/.866	.....	50	3.12	89.6	1,800	17.0	1123	8.7

* Probable.

ENGLISH SHIP AND

[From "List of Service Rifled Ordnance, corrected up to De-

Royal Gun Factory, 80-ton gun, steel tube, with wrought-iron coils.	16.0	80	26.8	18	Prismatic	450	.924	2.5	1,700	3.78	105.4	1,604	18.6	30319	25.0
Royal Gun Factory, 38-ton gun, steel tube, with wrought-iron coils.	12.5	38	19.2	15.8	P²	160	.....	.....	818	5.11	104.1	1,445	.....	11842	17.8
					Prismatic	210	.....	2.5	818	3.89	104.1	1,546	.....	13554	19.0
Royal Gun Factory, 35-ton gun, steel tube, with wrought-iron coils.	12.0	35	16.3	13.5	P²	140	.....	2.5	714	5.1	109.8	1,390	.....	9563	16.3
Royal Gun Factory, 25-ton gun, steel tube, with wrought-iron coils.	12.0	25	15.2	12.0	P	85	.....	2.5	614	7.16	91.2	1,300	.....	7029.4	14.2
Royal Gun Factory, 25-ton gun, steel tube, with wrought-iron coils.	11.0	25	15	13.2	P	85	.....	2.5	547	6.32	102.4	1,315	.....	6559	14.2
Royal Gun Factory, 18-ton gun, steel tube, with wrought-iron coils.	10.0	18	15	14.6	P	70	.....	2.5	410	5.85	98.4	1,364	.....	5288	13.4
Royal Gun Factory, 12-ton gun, steel tube, with wrought-iron coils.	9.0	13	13.3	14	P	50	.....	2.5	258	5.16	109.0	1,420	.....	3607	11.6
Royal Gun Factory, 9-ton gun, steel tube, with wrought-iron coils.	8.0	9	12	14.8	P	35	.....	2.5	180	5.16	112.0	1,413	.....	2492	9.9
Royal Gun Factory, 7-ton gun, steel tube, with wrought-iron coils.	7.0	7	12.4	18	P	30	.....	2.5	115	3.83	136.3	1,540	.....	1891	9.0
Royal Gun Factory, 6½-ton gun, steel tube, with wrought-iron coils.	7	6.5	11.1	15.9	P	30	.....	2.5	115	3.83	126.6	1,525	.....	1854	8.9

CHARGES, POWER, RANGE, &c, APPROXIMATELY—Continued.

COAST B. L. CANNON.

At muzzle.		At 1,000 yards.		At 2,000 yards.		At 3,500 yards.		Maximum elevation from carriage (fixed platform).	Corresponding range.	Computed ranges at elevation of—				Date of firing.	Remarks.
Energy per pound of powder.	Relative weight of gun to energy of projectile.	Total energy (smashing effect).	Penetration in iron.	Total energy (smashing effect).	Penetration in iron.	Total energy (smashing effect).	Penetration in iron.			10°	15°	20°	25°		
Ft-tons.	*Tons.*	*Foot-tons.*	*Inches.*	*Foot-tons.*	*Inches.*	*Foot-tons.*	*Inches.*	*Degrees.*	*Yards.*	*Yards.*	*Yards.*	*Yards.*	*Yards.*		
50.95	17.01	12944.1	20.7	10969.5	19.1	8496.7	16.8	.....	.....	8,863	11,142	12,885	14,227	.....	Prof. Papers R. E. 1883.
55.958	18.585	11636.2	19.7	9684.8	18.	7290.7	15.6	9	.....	.....	.....	.....	.....	1883	"Engineer," Feb. 8, 1884.
58.4	19.97	11671	19.8	9732	18.	.....	.....	.....	.....	.....	.....	.....	.....	.....	
51.731	18.313	7892.9	16.9	6326.6	15.2	4481.1	12.8	.....	.....	.....	.....	.....	.....	1883	Do.
56.278	19.384	7466.19	16.5	5975.0	14.8	4224.49	12.4	.....	.....	.....	.....	.....	.....	1883	Do.
54.275	16.584	9036.0	18.1	7496.8	16.5	5611.2	14.3	.....	.....	8,165	10,285	11,912	13,168	.....	Prof. Papers R. E. 1883.
50.697	10.759	13824.9	22.4	11368.1	20.3	8623.2	17.7	.....	.....	10,416	12,727	14,464	15,789	.....	Journal R. U. Service Institution, 1884.
51.375	20.022	8439.5	17.7	7103.8	16.3	5591.1	14.4	.....	.....	.....	.....	.....	.....	1883	"Steel Gun Factory," 1884.
56.834	17.862	9496.8	18.8	8029.9	17.3	6195.3	15.2	.....	.....	.....	.....	.....	.....	1883	Ord. Board Report, June 14, 1884.
57.4	20.30	5268	14.9	4050	13.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	Office of Naval Intelligence.
59.98	21.673	4664.3	14.0	3599.7	12.3	2416.1	9.7	.....	.....	7,233	9,026	10,402	11,460	.....	Prof. Papers R. E. 1883.
56.05	17.84	3796	13.6	2872	11.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	Office of Naval Intelligence.
49.517 58.333	14.585 15.918	1981.9 1809.6	10.6 9.7	1450.2 1320.1	8.4 7.9	924.44 854.1	6.3 6.0	}	.....	6,517	8,157	9,406	10,368	.....	Prof. Papers R. E. 1883.
59.063	8.462	2765.7	12.5	2146.3	11.0	1448.3	8.4	.....	.....	7,404	9,222	10,621	11,695	1881	Getty Board Report, 1882.
59.03	13.38	2612	12.1	1941	10.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	Office of Naval Intelligence.
52.718	15.174	866.03	6.8	560.62	5.2	3428.7	3.7	.....	.....	5,668	7,032	8,070	8,860	.....	Royal Engineer's Journal, 1885.
70.1	17.81	737	*6.7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	

* Thin plates.

COAST M. L. CANNON.

cember 1, 1883," Professional Papers Royal Engineers, 1883.]

67.377	26.385	20593	23.5	2329.6	22.0	1917.2	20.0	.....	.....	6,707	8,900	10,624	12,011	.....	Mark 1.
74.012 64.543	32.089 28.036	10015.4 11454.9	16.4 17.5	8542.6 9701.4	15.1 16.1	6851.3 7696.1	13.6 14.4	.....	.....	.....	.....	.....	.....	.....	Mark 1. Mark 2.
68.307	36.599	8042.3	15.0	6839.2	13.8	5526.6	12.5	.....	.....	6,009	7,924	9,485	10,707	.....	
82.699	35.564	5044.6	12.9	5002.3	11.9	4176.6	10.9	.....	.....	.....	.....	.....	.....	.....	Mark 1.
77.164	38.115	5465.7	12.9	4625.7	11.9	3845.9	10.9	.....	.....	.....	.....	.....	.....	.....	Mark 2.
75.543	34.089	4305.5	12.0	3567.1	11.0	2889.5	9.4	.....	.....	.....	.....	.....	.....	.....	Mark 2.
72.140	36.041	2757.0	9.8	2168.0	8.4	1698.0	7.2	.....	.....	.....	.....	.....	.....	.....	Mark 2.
71.20	36.115	1848.5	8.2	1420.0	6.9	1107.2	5.9	.....	.....	.....	.....	.....	.....	.....	Mark 5.
63.03	37.017	1304.4	7.1	989.86	5.8	692.16	4.8	.....	.....	.....	.....	.....	.....	.....	Mark 3.
61.8	35.059	1280.3	7.1	926.06	5.6	685.79	4.8	.....	.....	.....	.....	.....	.....	.....	Mark 4.
															Mark 3.

TABLE I.—PRINCIPAL DIMENSIONS, WEIGHTS,

Nature of cannon.	Caliber.	Weight.	Total length.	Length of bore.	Powder.			Projectile.		Ratio of weight of charge to weight of projectile.	Ratio of weight of projectile to weight of piece.	Initial velocity.	Pressure.	At muzzle.	
					Kind.	Weight.	Density of loading.	Length.	Weight.					Total energy (smashing effect).	Penetration in iron.
	Inches.	*Tons.*	*Feet.*	*Calibers*		*Pounds.*		*Calibers*	*Pounds.*			*Feet.*	*Tons.*	*Foot-tons.*	*Inches.*
SPANISH RIFLED															
10cm gun, steel	6.3	6.2	.....	33.5	Prismatic...	77	.....	.....	132	1.71	105.21	2,133	14.8	4163	14.7
FRENCH SHIP AND COAST															
All steel construction.															
42cm gun (under fabrication 1875).	16.5	75	32	22	.....	617	.....	.....	1,726	2.8	97.9	1,738	.....	36171.5	26.9
37cm gun (under fabrication)	14.6	72	36.7	28.5	.....	546	.....	.....	1,177	2.2	142.7	1,955	.....	31185	26.5
34cm gun (under fabrication)	13.4	52.5	33.5	28.5	.....	462	.....	.....	926	2.0	140.3	1,968	.....	24861	24.8
27cm gun	10.6	30	27.1	28.5	.....	237	.....	.....	475	2.0	140.5	1,955	.....	12586	19.7
Cast-iron hooped, and tubed with steel.															
32cm gun, model, 1870 M	12.6	38	22	19.2	W. $\frac{19}{28}$	196	0.850	2.4	759	3.9	112.2	1,575	16.5	13951.7	18.6
27cm gun, model, 1870 M	10.8	22.7	17.7	18	W. $\frac{19}{28}$	142	0.878	2.4	475	3.3	107.0	1,608	16.5	8513.9	16.2
24cm gun, model, 1870 M	9.45	15.4	16.2	18.1	W. $\frac{25}{36}$	102	0.818	2.3	317	3.1	108.8	1,624	16.5	5795.5	14.4
19cm gun, model, 1870 M	7.6	7.8	13.6	19.8	W. $\frac{25}{36}$	59.4	0.960	2.4	165	2.8	105.9	1,739	17.1	3458.9	12.4
16cm gun, model, 1870 M	6.3	5	.....	21.0	W. $\frac{25}{36}$	42.6	0.953	2.4	99	2.1	113.1	1,722	16.5	2179.3	10.8
Rifled mortar, steel, land service.															
27cm mortar	10.63	4	.....	8.1	S. P.	34	.....	2.7	360	10.6	24.9	820	.....	1678.0	6.4
M. L. rifled mortar, cast-iron, steel hooped, marine artillery.															
30cm mortar	11.81	10.5	.....	9.3	.....	40	.....	.....	484	12.1	48.1	.....	.....	.....	.....
24cm mortar	9.45	6	.....	10.2	.....	22	.....	.....	264	12.0	50.9	.....	.....	.....	.....
ITALIAN COAST															
Cast-iron hooped, with steel construction.															
45cm gun	17.72	100	30.8	20.8	Fossano.	485	.....	2.3	2,204	4.5	101.6	1,512	14.5	35037	25.5
32cm gun	12.6	38	22.5	20	Fossano.	187	.....	2.4	770	4.1	110.5	1,490	10.5	11850.3	17.7
24cm gun	9.45	17	18.6	22	.....	62	.....	2.5	330	5.3	115.4	1,427	.....	4658.3	12.9
RUSSIAN SHIP AND COAST															
Steel cannon.															
16-inch gun	16	78	30.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14-inch gun	14	57	25.4	19.3	.....	294	.....	.....	1,250	4.3	102.3	1,530	.....	18305	.....
11-inch gun	11	42	32	.....	.....	136	.....	.....	609	4.5	154.5	1,312	.....	.....	.....

CHARGES, POWER, RANGE, &c., APPROXIMATELY—Continued.

B. L. CANNON.

At muzzle.		At 1,000 yards.		At 2,000 yards.		At 3,500 yards.		Maximum elevation from carriage (fixed platform).	Corresponding range.	Computed ranges at elevation of—				Date of firing.	Remarks.
Energy per pound of powder.	Relative weight of gun to energy of projectile.	Total energy (smashing effect).	Penetration in iron.	Total energy (smashing effect).	Penetration in iron.	Total energy (smashing effect).	Penetration in iron.			10°	15°	20°	25°		
Ft-tons.	*Tons.*	*Foot-tons.*	*Inches.*	*Foot-tons.*	*Inches.*	*Foot-tons.*	*Inches.*	*Degrees.*	*Yards.*	*Yards.*	*Yards.*	*Yards.*	*Yards.*		
54.1	14.4	32.41	13.3	.....	.....	1698	9.0	.....	.....	.....	.....	.....	.....	.....	*Memorial de Artilleria*, July and December, 1884; *Rivista di Artiglieria e Genio*, August, 1884.

RIFLED B. L. CANNON.

52.576	20.751	31610	25.1	27570.8	23.5	22384.7	21.25	.....	.....	.....	.....	.....	.....	.....	Journal, Royal United Service Institution, No. cxxvi, 1884.
57.115	23.088	26856.3	24.6	23061.1	22.85	18235.8	20.4	.....	.....	.....	.....	.....	.....	.....	
53.826	21.111	21188	22.9	17999	21	13968	18.6	.....	.....	.....	.....	.....	.....	.....	*Revue d'Artillerie.*
53.105	23.836	10269	17.8	8334.9	16.1	6034.8	13.7	.....	.....	.....	.....	.....	.....	.....	
66.590	29.114	10863	17.0	9051.3	15.5	7028.6	13.8	.....	.....	6,024	7,910	9,411	10,597	1880	*Artillerie de la Marine, Carnet de Notes et Renseignements*, Captain Gadaud, 1881.
59.957	26.662	6867.7	14.6	5547.6	13.2	4145.2	11.4	.....	.....	5,920	7,714	9,125	10,236	1880	
56.819	26.571	4531.4	12.7	3552.7	11.3	2572.1	9.1	.....	.....	5,755	7,449	8,785	9,829	1880	
58.232	22.549	2559.8	10.7	1887.2	8.6	1275.0	6.7	.....	.....	5,796	7,382	8,470	9,448	1880	
51.157	22.943	1545.7	8.5	1092.1	6.9	720.0	5.3	35	9,592	5,666	7,161	8,315	9,204	1880	Ordnance Notes, No. 208.
49.353	23.892	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*Artillerie de la Marine*, 1881, Gadaud.
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*Artillerie de la Marine*, 1881, Gadaud. Penetration in iron 30cm=3.5 inches. Penetration in iron 24cm=2.5 inches.

RIFLED B. L. CANNON.

72.017	28.629	30803	24.0	27196.9	22.5	22762.7	20.7	20	.....	6,222	8,337	10,042	11,408	.....	*Giornale di Artiglieria e Genio*, 1881, part 2; 1880, part 2.
63.37	32.066	9884.2	16.2	8300.2	14.9	6541.1	13.2	30	.....	5,500	.....	8,749	.....	.....	Table of Fire, 1877.
75.134	36.494	3689.6	11.5	2978.1	9.9	2335.8	8.5	9, 10, 32	.....	.....	.....	.....	.....	.....	Practical Instructions, 1879.

RIFLED B. L. CANNON.

.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Russian Artillery Journal, 1883.
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	

The penetrations in iron on the foregoing pages were computed by Capt. W. S. Starring, Lieuts. C. H. Clark and F. E. Hobbs, Ordnance Department, U. S. A., except where the data is noted as having been obtained from the office of Naval Intelligence; the ranges were computed by Lieut. O. B. Mitcham, Ordnance Department, U. S. A.

TABLE II.—THE ACTUAL RANGES AND ACCURACY OF FIRE OBTAINED IN PRACTICE WITH HEAVY RIFLED CANNON.

KRUPP'S 40-CENTIMETER B. L. GUN (25 *calibers length*).

[Source of information: *Expériences de Tir*, Meppen, 1879.]

Date of firing.	Number of shots.	Caliber.	Weight.	Total length.	Length of bore.	Powder.			Projectile.		Initial velocity.	Angle of elevation.	Time of flight.	Mean range.	Dispersion.			Mean deviation.			Area containing 50 per cent. of hits.		
						Nature.	Weight.	Density of loading.	Length.	Weight.					In range.	In direction.	In height.	In range.	In direction.	In height.	Length.	Width.	Height.
1879.		*Inch.*	*Tons.*	*Feet.*	*Cals.*		*Lbs.*		*Cals.*	*Lbs.*	*Feet.*	° ′	*Sec.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*
Aug. 5	10	15.75	71.0	32.8	21.78	Black prismatic.	451	.862	2.8	1,709	1,652	*3 0	.....	2,814	9.84	1.97	0.49	2.87	0.77	0.18	.....	.....	...
Aug. 6	6					....do.....	440	.840	2.8	1,411	1,769	*2 40	.....	2,816	21.87	2.30	0.44	6.86	0.68	0.16	.....	.....	....

*Approximate elevations.

KRUPP'S 35.5-CENTIMETER GUN B. L. (30 *calibers length*).

[Source of information: *Expériences de Tir*, Nos. 33–36.]

Date of firing.	Number of shots.	Caliber.	Weight.	Total length.	Length of bore.	Powder.			Projectile.		Initial velocity.	Angle of elevation.	Time of flight.	Mean range.	Dispersion.			Mean deviation.			Area containing 50 per cent. of hits.		
						Nature.	Weight.	Density of loading.	Length.	Weight.					In range.	In direction.	In height.	In range.	In direction.	In height.	Length.	Width.	Height.
1882.																							
Apr. 20, May 8	1					Black prismatic.	220	.633	2.8	1,158	1,435	4 7	.....	2,886	.....	.....	.....	.....	.....	.....	.....	.....	....
Apr. 20, May 8	1					....do.....	265	.758	2.8	1,158	1,572	3 40	.....	3,031	.....	.....	.....	.....	.....	.....	.....	.....	....
May 10	1					....do.....	265	.758	2.8	1,158	1,572	8 0	.....	5,769	.....	.....	.....	.....	.....	.....	.....	.....	....
Apr. 20, May 8	3	13.98	57.5	34.9	26.8	....do.....	313	.897	2.8	1,158	1,721	2 17	.....	2,228	.....	1.25	0.93	.....	0.49	0.32	.....	0.84	0.56
Apr. 20, May 8	3					....do.....	313	.897	2.8	1,158	1,721	4 0	.....	7,012	40.5	0.77	.....	16.5	0.33	.....	.....	27.9	0.54
May 10	3					....do.....	313	.897	2.8	1,158	1,721	6 0	.....	5,188	29.5	2.07	.....	10.4	0.77	.....	17.6	1.31	....
May 10	3					....do.....	313	.897	2.8	1,158	1,721	12 0	19.8	8,380	73.2	8.02	.....	24.8	3.39	.....	42.0	5.68	....
May 10	3					....do.....	313	.897	2.8	1,158	1,721	18 0	29.7	11,193	131.2	6.78	.....	51.5	2.03	.....	87.1	3.88	....

KRUPP'S 35.5-CENTIMETER B. L. GUN (25 *calibers length*).

[Source of information: *Expériences de Tir*, Meppen, 1879.]

Date of firing.	Number of shots.	Caliber.	Weight.	Total length.	Length of bore.	Powder.			Projectile.		Initial velocity.	Angle of elevation.	Time of flight.	Mean range.	Dispersion.			Mean deviation.			Area containing 50 per cent. of hits.		
						Nature.	Weight.	Density of loading.	Length.	Weight.					In range.	In direction.	In height.	In range.	In direction.	In height.	Length.	Width.	Height.
1878.																							
July 2, 3	10	13.98	51.1	29.1	21.8	Black prismatic.	254	1.00	2.8	1,158	1,630	*2 30	.....	2,246	52.5	1.47	2.62	.....	.....	.....	.....	.....	....
July 2, 3	10					....do.....	254	1.00	2.0	1,158	1,630	*6 0	.....	4,420	85.3	0.03	.....	29.4	.01	.....	.....	.....	....
July 2, 3	10					....do.....	254	1.00	2.8	1,158	1,630	17 0	.....	10,331	137.8	13.12	.....	38.2	3.06	.....	.....	.....	....

*Approximate elevations.

KRUPP'S 30.5-CENTIMETER B. L. GUN (35 *calibers length*).

[Source of information: *Expériences de Tir*, Nos. 31, 47.]

Date of firing.	Number of shots.	Caliber.	Weight.	Total length.	Length of bore.	Powder.			Projectile.		Initial velocity.	Angle of elevation.	Time of flight.	Mean range.	Dispersion.			Mean deviation.			Area containing 50 per cent. of hits.		
						Nature.	Weight.	Density of loading.	Length.	Weight.					In range.	In direction.	In height.	In range.	In direction.	In height.	Length.	Width.	Height.
1882.																							
Mar. 23	5	12.0	48.0	35.1	32.0	Black prismatic.	325	.833	3.5–4.5	1,003	1,720	2 18	.....	2,266	.....	.....	.....	.....	.....	.....	1.15	0.35	....
Mar. 30	10					....do.....	325	.833	3.5–4.5	1,003	1,720	15 0	.....	10,288	187.5	15.03	.....	59.6	4.01	.....	101.00	6.09	....
1883.																							
Aug. 18	3					Brown prismatic.	357	.917	3.5	1,003	1,857	14 0	24.7	10,706	63.4	4.34	.....	.....	.....	.....	.....	.....	....
Aug. 18	3					....do.....	357	.917	2.5	622	2,156	14 0	25.5	11,093	38.3	3.28	.....	.....	.....	.....	.....	.....	....

KRUPP'S 30.5-CENTIMETER B. L. GUN (25 *calibers length*).

[Source of information: *Expériences de Tir*, No. 48.]

Date of firing.	Number of shots.	Caliber.	Weight.	Total length.	Length of bore.	Powder.			Projectile.		Initial velocity.	Angle of elevation.	Time of flight.	Mean range.	Dispersion.			Mean deviation.			Area containing 50 per cent. of hits.		
						Nature.	Weight.	Density of loading.	Length.	Weight.					In range.	In direction.	In height.	In range.	In direction.	In height.	Length.	Width.	Height.
1883.																							
Sept. 25	8	12.0	37.0	25.0	22.0	Brown prismatic.	265	.855	3.5	1,003	1,535	5 50	.....	4,420	67.8	4.07	6.45	20.2	1.31	2.06	34.62	3.03	3.5
Sept. 25	10					....do.....	265	.855	3.5	1,003	1,535	8 30	13.8	5,921	71.1	14.02	.....	17.9	3.09	.....	33.03	6.06	....

TABLE II.—THE ACTUAL RANGES AND ACCURACY OF FIRE OBTAINED IN PRACTICE WITH HEAVY RIFLED CANNON—Continued.

KRUPP'S 28-CENTIMETER GUN (35 *calibers length*).

[Source of information: *Expériences de Tir*, No. 32.]

Date of firing.	Number of shots.	Caliber.	Weight.	Total length.	Length of bore.	Powder.			Projectile.		Initial velocity.	Angle of elevation.	Time of flight.	Mean range.	Dispersion.			Mean deviation.			Area containing 50 per cent. of hits.		
						Nature.	Weight.	Density of loading.	Length.	Weight.					In range.	In direction.	In height.	In range.	In direction.	In height.	Length.	Width.	Height.
1882.		*Inch.*	*Tons.*	*Feet.*	*Cals.*		*Lbs.*		*Cals.*	*Lbs.*	*Feet.*	° ′	*Sec.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*
June 1	10					Black prismatic.	254	.861	3.5	760	1,734	2 23	.....	2,260	26.24	0.73	1.53	7.1	0.22	0.43	12 0	0.36	0.72
June 6	10					....do	254	.861	3.5	760	1,734	4 54	8.8	4,419	57.96	2.73	5.57	13.6	0.61	1.36	22.96	1.03	2.28
June 5	10					....do	254	.861	3.5	760	1,734	8 30	14.6	6,790	157.4	9.84	.....	31.4	2.07	.....	53.0	3.28	....
June 3	5	11.024	37	32.2	32	....do	254	.861	3.5	760	1,734	17 15	27.5	11,210	189.2	18.6	.....	63.4	5.24	.....	98.9	8.86	..
June 1	10					....do	254	.861	3.5	653	1,844	2 11	.....	2,196	21.9	0.98	1.09	6.12	0.26	0.32	10.38	0.45	0.52
June 5	5					...do	254	.861	3.5	653	1,844	8 0	14.0	6,786	70.0	8.75	.....	21.0	2.4	.....	53.0	3.28	....
June 3	5					....do	254	.861	3.5	653	1,844	17 15	27.8	11,386	159.6	16.4	.....	54.3	6.45	.....	91.9	10.9	....

KRUPP'S 15-CENTIMETER GUN (35 *calibers length*).

[Source of information: *Expériences de Tir*, No. 31.]

Date of firing.	Number of shots.	Caliber.	Weight.	Total length.	Length of bore.	Powder. Nature.	Powder. Weight.	Powder. Density of loading.	Projectile. Length.	Projectile. Weight.	Initial velocity.	Angle of elevation.	Time of flight.	Mean range.	Dispersion. In range.	Dispersion. In direction.	Dispersion. In height.	Mean deviation. In range.	Mean deviation. In direction.	Mean deviation. In height.	Area containing 50 per cent. of hits. Length.	Area containing 50 per cent. of hits. Width.	Area containing 50 per cent. of hits. Height.
1882.																							
Mar. 30	10	5.87	4.7	17.1	32	Black prismatic.	37.5	.....	4.0	112.4	1,749	2 23	.....	2,215	.....	1.42	2.7	.....	0.35	0.81	.....	0.59	1.35
Mar. 29	10					....do	37.5	.....	4.0	112.4	1,749	20 0	.....	9,743	336.0	53.6	.....	74.8	14.1	.....	23.8	12.64	....

KRUPP'S 28-CENTIMETER HOWITZER.

[Source of information: *Firing experiments* at Meppen, 1879.]

Date of firing.	Number of shots.	Caliber.	Weight.	Total length.	Length of bore.	Powder. Nature.	Powder. Weight.	Powder. Density of loading.	Projectile. Length.	Projectile. Weight.	Initial velocity.	Angle of elevation.	Time of flight.	Mean range.	Dispersion. In range.	Dispersion. In direction.	Dispersion. In height.	Mean deviation. In range.	Mean deviation. In direction.	Mean deviation. In height.	Area containing 50 per cent. of hits. Length.	Area containing 50 per cent. of hits. Width.	Area containing 50 per cent. of hits. Height.
1879.																							
Apr. 12	3					Black prismatic.	15.4	.243	2.8	475	520	60 0	.....	2,166	44.6	6.6	.....	17.1	3.43	.....	28.8	4.15	....
	5						.....	.....	.....	.....	.....	30 0	.....	2,300	62.0	6.0	.....	26.6	1.53	.....	44.8	2.62	....
Mar. 20	5					....do	19.8	.365	2.8	475	673	60 0	.....	3,545	98.4	12.0	.....	26.3	4.9	.....	44.5	8.3	....
	5	11.024	10	10.5	9		.....	.....	.....	.....	.....	30 0	.....	3,877	42.7	5.6	.....	18.2	15.3	.....	30.7	2.62	....
Mar. 20	9					....do	39.6	.730	2.8	475	984	28 36	.....	7,404	104.0	6.5	.....	28.8	1.7	.....	49.2	2.84	....
	9						..	.....	.....	.....	.....	6 19	.....	2,221	48.1	2.5	5.6	16.4	0.52	1.4	19.4	0.87	2.4
Mar. 14	9					....do	42	.771	2.8	475	1,017	45 0	.....	8,541	146.0	35.3	. ...	35.1	4.5	.....	59.4	7.7	....

KRUPP'S 24-CENTIMETER GUN (30 *calibers length*).

[Source of information: *Expériences de Tir*, No. 56, February, 1885.]

Date of firing.	Number of shots.	Caliber.	Weight.	Total length.	Length of bore.	Powder. Nature.	Powder. Weight.	Powder. Density of loading.	Projectile. Length.	Projectile. Weight.	Initial velocity.	Angle of elevation.	Time of flight.	Mean range.	Dispersion. In range.	Dispersion. In direction.	Dispersion. In height.	Mean deviation. In range.	Mean deviation. In direction.	Mean deviation. In height.	Area containing 50 per cent. of hits. Length.	Area containing 50 per cent. of hits. Width.	Area containing 50 per cent. of hits. Height.
1884.																							
Dec. 9–11	10										1,736	2 19	.....	2,216	25.2	0.66	1.42	6.2	2.29	4.48	10.5	0.393	0.77
Dec. 9–11	10										.....	3 41	.....	3,281	30.62	3.61	2.00	9.18	1.09	4.92	15.52	1.85	0.83
Dec. 9–11	10	9.45	18.9	23.6	30	Brown prismatic.	150	0.911	3.5	474	.....	5 10	.....	4,375	32.8	3.61	3.73	10.61	0.80	1.00	17.94	1.31	1.70
Dec. 9–11	10										.....	8 35	.....	6,586	50.3	5.47	.....	16.73	1.31	.....	28.32	2.19	....
Dec. 9–11	10										.....	12 5	.....	8,352	76.55	5.47	....	20.67	1.42	.....	34.9	2.41	....

ITALIAN 100-TON GUN, CAST IRON, HOOPED WITH STEEL, LAND SERVICE.

[Source of information: Ordnance Notes, No. 174.]

Date of firing.	Number of shots.	Caliber.	Weight.	Total length.	Length of bore.	Powder. Nature.	Powder. Weight.	Powder. Density of loading.	Projectile. Length.	Projectile. Weight.	Initial velocity.	Angle of elevation.	Time of flight.	Mean range.	Dispersion. In range.	Dispersion. In direction.	Dispersion. In height.	Mean deviation. In range.	Mean deviation. In direction.	Mean deviation. In height.	Area containing 50 per cent. of hits. Length.	Area containing 50 per cent. of hits. Width.	Area containing 50 per cent. of hits. Height.
1880.																							
June 30	5					Fossano	485	.773	2.3	2,205	1.480	3 0	.....	2,129	14.2*	5.25†	.....	.....	.....	.....	.....	.....	....
July 2	5					....do	485	.773	2.3	2,205	1,480	6 42	.....	4,520	35.6*	0. †	....	.....	.....	.....	.....	.....	....
July 4	5					... do	485	.773	2.3	2,205	1,480	11 0	.....	6,355	108.3‡	28.54§	.....	.....	.....	.....	.....	.....	....
July 4	5	17.72	100	30.8	20.8	....do	485	.773	2.3	2,205	1,480	15 0	.....	8,467	200.1	30.5	.....	.....	.....	....	.....	.....	....
Jan'y 27	1					....do	485	.773	2.3	2,205	1,492	10 0	16	6,496	.....	.....	.....	.....	.....	.....	.....	.....	....
Jan'y 27	1					....do	485	.773	2.3	2,205	1,492	15 0	23	8,552	....	....	.....	.....	.....	.....	.....	.....	....
Jan'y 27	1					....do	485	.773	2.3	2,205	1,492	20 0	30	10,665	.....	.....	.....	.....	.....	.....	.....	.....	....

* Right. † Left. ‡ Range. § Direction.

TABLE II.—THE ACTUAL RANGES AND ACCURACY OF FIRE OBTAINED IN PRACTICE WITH HEAVY RIFLED CANNON—Continued.

ARMSTRONG'S 11½-TON M. L. GUN.

["Engineer," November 5, 1880.]

Date of firing.	Number of shots.	Caliber.	Weight.	Total length.	Length of bore.	Powder.			Projectile.		Initial velocity.	Angle of elevation.	Time of flight.	Mean range.	Dispersion.			Mean deviation.			Area containing 50 per cent. of hits.		
						Nature.	Weight.	Density of loading	Length.	Weight.					In range.	In direction.	In height.	In range.	In direction.	In height.	Length.	Width.	Height.
		Inch.	*Tons.*	*Feet.*	*Cals.*		*Lbs.*		*Cals.*	*Lbs.*	*Feet.*	° ′	*Sec.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*
1880.	....	8	11.5	18.21	26	Pellet	90	.789	2.5	182	2,030	10 0	.....	8,402	.....	.....	.....	.....	.....	.....	.....	.....	....

GENERAL REMARKS.

In his testimony before the House Committee on Naval Affairs, 1882, page 32, Lieutenant Very, United States Navy, gives as the computed range of the 100-ton gun, 17-inch caliber, with a projectile of 2,100 pounds and a velocity of 1,765, and under an angle of 41°, a range of 13 miles; but he states that, as the maximum elevation on board ship is about 13°, it would be necessary to list the ship in 26° in order to obtain 41°; and he adds that no commander of a man-of-war would dare to list his ship to that degree and fire a gun of that weight.

There is claimed for the English 10-inch B. L. rifle, of 32 calibers length of bore, a range of 8 miles; for the French 37-centimeter (14.6 inch) B. L. rifle (Dard), a range of 11 miles ("Army and Navy Gazette," May 15, 1884).

Time of loading and firing heavy guns.

For the 100-ton gun the minimum time is about 5 minutes; average time, 15 minutes (Ordnance Notes, No. 174; Journal Royal U. S. Institution, No. 128, for 1885); for Krupp's 12-inch rifle, 35 calibers length, the time is 7 minutes per round, without including the pointing of the gun (Ordnance Notes, No. 221).

TABLE III.—MATERIAL, DIMENSIONS, WEIGHTS, &c., OF EXPERIMENTAL

Place and date.	Plate or target.									Gun.			
	Material and peculiarity.	Maker.	Length.	Breadth.	Thickness.	Weight.	Backing.	Bolts.	Distance from gun.	Nature.	Caliber.	Weight.	Length of bore.
					In.	*Tons.*			*Yds.*		*Inches.*	*Tons.*	*Cals.*
Portsmouth, Aug., 1883.	Compound—½ steel, ⅜ iron.	Brown	6′ 2′	6′ 0″	4½	3			10	Woolwich M. L. R.	7	6.5	15.9
Shoeburyness, June, 1877.	Compound—½ steel, ½ iron.	do			5				30	do	7	6.5	15.9
Do	do	do								do	7	6.5	15.9
Do	do	do								do	7	6.5	15.9
Nettle at Portsmouth, June, 1882.	Compound—½ steel, ⅜ iron, curved horizontally and vertically.	Cammell	8	7	(†)				10	do	7		15.9
Shoeburyness, Oct., 1879.	Wrought iron				6					Armstrong M. L. R., chambered.	8	11½	26
France, Apr., 1884	Compound—½ steel, ⅜ iron.	**C. & C	.85	6	7.87	6.56	Wood	Schneider bolts		French B. L. R., 19cm.	7.48		19.8
Kummersdorf, 1881	do	Cammell			8					Krupp, 17cm	6.69		
Do	do	do			8					do	6.69		
Shoeburyness, Mar., 1879.	Wrought iron				8		None			Armstrong B. L. R.	6	3	23
Do	do				8		do			do	6	3	23
Shoeburyness, Oct., 1879.	do				8		do			Armstrong M. L. R., chambered.	8	9	26
Shoeburyness, 1877	Compound—5″ hard steel, 4″ iron.				9				30	Woolwich M. L. R.	7	6.5	15.9
Do	Compound—4½″ soft steel, 4½″ iron.				9				30	do	7	6.5	15.9
Shoeburyness, Aug., 1877.	Compound—5″ steel, 4″ iron.	Cammell	3′ 10″	3′ 8″	9	2.3			23	do	7	6.5	15.9
Nettle at Portsmouth, Dec., 1877.	Untempered, compressed steel; pitted with 50 plugs of hard steel.	Whitworth	6′ 8″	6′ 0″	9	6.6	Stout timber	2½-inch steel	10	do	9	12	14.8
Do	Steel, subcarburized	Cammell	9′ 9″	7.9	9	11.2	do	do	10	do	9	12	14.8
Do	Compound—iron face and back—¾″ and 1¾″, 6½″ steel.	do	8′ 0″	5′ 11″	9	7.8	do	do	10	do	9	12	14.8
Do	Compound—4″ steel, 5″ iron.	do	9′ 9″	7′ 1½″	9	11.2	do	do	10	do	9	12	
Do	Wrought iron	do	9′ 9″	7′ 9″	9	12.2	do	do	10	do	9	12	14.8
Nettle at Portsmouth, Feb., 1878.	Compound—½ steel, ½ iron.	Brown	7′ 9″	6′ 8″	9	8.4	do	Navy		Woolwich M. L. R.	9	12	14.8
Do	do	do	7′ 6″	6′ 7″	9		do	do		do	9	12	14.8
May, 1878	Steel, oil tempered	Cammell			9								
Do	Steel, soft	do			9								
Do													

** Chatillon & Commentry, St. Chamond, France. † Tapered from 6 to 4; average 5. Penetrations by R. A. formula (thin plates formula up to and including 9″ thickness).

ARMOR-PLATES OR TARGETS, WITH RESULTS OF TRIAL.

Powder.		Projectile.		Velocity.		Energy at impact.		Penetration.		
Kind.	Weight.	Class, material, and maker.	Weight.	At muzzle.	At impact.	Total smashing effect.	Per ton of weight of plate.	Calculated.	Actual.	Effects from impact and ultimate resistance of plate or target, general remarks, sources of information, &c.
	Lbs.		*Lbs.*	*Feet.*	*Feet.*	*Ft. tons.*	*Ft. tons.*	*Inches.*	*Inches.*	
P	8	Palliser; chilled iron.	114							Projectile broke up. Plate bulged and slightly cracked at rear. Still good. Photograph from John Brown & Co.
..do	8½	...do	113						3½	Face hardened; 0.5 per cent. carbon. (*T., p. 32.)
..do	23	...do	113	1,525		§1,854		8.9		Shell just forced its point through and broke up.
..do	25	...do	113	1,525		1,854		8.9		Not so satisfactory. Still good. Face soft.
P²	14	Palliser; chilled iron.	115		1,230	1,206	241	6.8	3.55	Back of plate bulged and cracked behind each impact. For I. R. S. Vladimir Monomach. (†V., p. 494 Cammell & Co's pamphlet.)
R. L. G	20	Palliser; 1½ cal.; ogival; chilled iron.	182.4	962	922	1,075		5.9	Practically complete.	Projectile whole. One of a series of firings in ‡E., p. 348.
		Chilled iron; C. & C.	165		1,437	2,297	350	10	3.7	Slight radial and concentric cracks. (Pamphlets issued by firm of Chatillon & Commentry.)
									4.9	Slight radial and concentric cracks. (Pamphlets issued by firm of Chatillon & Commentry.)
										Deeper cracks. Part of face knocked off. Still good. (Pamphlets issued by firm of Chatillon & Commentry.)
		Chilled iron; Gruson.							Complete	Point of shot through plate and 6″ into backing. Energy per inch of shot's circumference, 91 foot-tons. (V., p. 491.)
										Point of shot through plate and 17″ into backing. Energy per inch of shot's circumference, 92 foot-tons. (V., p 491.)
										Whole projectile through. Energy per inch of shot's circumference, 92 foot-tons. Plate condemned. (V., p. 491.)
		...do								Considerable bulging at back. No cracks. (V., p. 491.)
										As before, with a through crack across bulge. (V., p. 491.)
										As before, with a through crack across bulge. Point of shell visible. (V., p. 491.)
P	28	Steel	80	1,463	1,440	1,153		7.3	Complete	Pierced freely. Experimental series. (E., p. 344.)
..do	21.2	...do	100	1,283	1,260	1,104		7.1	Almost through.	Practically pierced. Head of projectile through by 6¼″. Experimental series. (E., p. 344.)
R. L. G	29	Chilled iron	182.4	1,142	1,122	1,595		7.5	..do	Practically pierced. Head of projectile broken. Experimental series. (E., p. 344.)
P	30	...do	113						3.5	Projectile broke up. Face of plate scored by fragments. .64 per cent. carbon (T., p. 32.)
..do	30	...do	113						5.5	Projectile broke up less than above. .48 per cent. carbon. (T., p. 32.)
..do	30	Palliser; chilled iron.	113						3.2	Patch off steel face. Radiating cracks. (V., p. 472. Engineer, 17, 8, 77.)
..do	50	...do	250	1,420	1,420	3,496	530	11.43	4.1 2.85	Each shot developed cracks which were opened out by succeeding ones. Third shot broke up. Penetration not observed. (V., p. 473; T., 28. *Engineer*, 21, 12, 77. Three shots at each target.)
	50	...do	250	1,420	1,420	3,496	312	11.4	2.75 to 7	Similar to preceding. .13 per cent. carbon.
	50	...do	250	1,420	1,420	3,496	448	11.4	Almost complete.	Same as preceding. Cracks wider. Upper corner knocked off.
	50	...do	250	1,420	1,420	3496	312	11.4		Penetrated until base was 1⅞″ beneath surface. 15″ into backing.
										Penetrated 9 inches into backing. Serious cracks. Third shot not fired.
	50	...do	250	1,420	1,420	3,496	286	11.4		One shot pierced completely, others nearly through.
P	50	...do	250	(‖)						Plate extensively cracked. Three projectiles, all broke up. (E., p. 310; T., p. 29.)
..do	50	...do	250	‖)						Plate cracked and starred in all directions. Third shot dislodged about a third. Projectile all broke up. Harder face. (E., p. 310; T., p. 29.)
										Broke down at second fire. (V., p. 476.)
									.7	First shot split the plate from side to side.
									Complete	Second and third shots went through. (V., p. 476.)

* T. Professional Papers Corps of Engineers No. 25.
† V. The Development of Armor for Naval Use, Lieutenant Very.
‡ E. *Expériences de tir contre les cuirasses.*
§ At muzzle.
‖ "Higher than preceding."

TABLE III.—MATERIAL, DIMENSIONS, WEIGHTS, &c., OF EXPERIMENTAL

Place and date.	Plate or target.									Gun.			
	Material and peculiarity.	Maker.	Length.	Breadth.	Thickness.	Weight.	Backing.	Bolts.	Distance from gun.	Nature.	Caliber.	Weight.	Length of bore.
					In.	*Tons.*			*Yds.*		*Inches.*	*Tons.*	*Cals.*
Nettle, May, 1878	Compound—¼ steel, ¾ iron.	Cammell	8′ 0″	6′ 8½″	9	8.7				Woolwich M. L. R.	9	12	14.8
May, 1878	Compound				9					do			
Manchester, 1878	Steel, hexagonal disks.	Whitworth			9				29	Woolwich M. L. R.	9	12	14.8
Nettle, July, Aug., 1879.	Compound—3½″ steel, 5½″ iron.	Cammell	7′ 9″	7	9		To represent turret of Inflexible.		10	Woolwich M. L. R.	9	12	14.8
Nettle, 1879	do	do	7′ 8″	5′ 9″	9	7.5				do	9	12	14.8
Nettle, Apr., 1880	Compound, curved to outside radius of 16′ 11″.	do	6	5′ 8″	9	5.5				do	9	12	14.8
Nettle, May, 1880	Compound—4″ steel, 5″ iron.	do			9				10	do	9	12	14.8
Amager, near Copenhagen, March, 1884.	Compound, curved to interior radius—10′9″.	Marrel	6′ 6.7″	4′ 11″	9	about 5¼	9″ wood over 2 iron plates .315″ thick.	11 Schneider	109	Armstrong M. L. R. and Krupp, 15cm.	10 5.9	18 4½	14.6 35
	do	Cammell	6′ 6.7″	4′ 11″	9.2	about 5¼	do	12 Schneider	109	do			
	do	Brown	6′ 6.7″	4′ 11″	9	5¼	do	12 Schneider	109	do			
	Steel, same curvature.	Schneider	6′ 6.7″	4′ 11″	9	5¼	do	16 Schneider	109	do			
Shoeburyness, 1877	Compound—4″ steel, 6″ iron.				10		None		50	Woolwich M. L. R.	9	12	14.8
Shoeburyness, Mar., 1879.	Wrought iron				10		do			Armstrong B. L. R.	6	3	23
Shoeburyness, Oct., 1879.	do				10		do			Armstrong M. L. R., chambered.	8	11½	26
Nettle, 1880	Compound—3.54″ steel, 7.06″ iron.	Brown	7′ 10½″	5′ 5″	10.6	9¼			10	Woolwich M. L. R.	9	12	14.8
Nettle, Sept., 1880	Compound—3″ steel, 8″ iron.	Cammell	7′ 0″	6′ 3″	11	8.7			10	do	9	12	14.8
Shoeburyness, 1882	Compound—4″ steel, 7″ iron.	Brown	10′ 0″	5′ 6″	11	10.9	24″ oak			do	9	12	14.8
											9	....	14.8
											9	.....	14.8
											9	12	14.8
									93		12.5	38	15.8
									93		12.5	38	15.8

ARMOR-PLATES OR TARGETS, WITH RESULTS OF TRIAL—Continued.

Powder.		Projectile.		Velocity.		Energy at impact.		Penetration.			
Kind.	Weight.	Class, material, and maker.	Weight.	At muzzle.	At impact.	Total smashing effect.	Per ton of weight of plate.	Calculated.	Actual.	Effects from impact and ultimate resistance of plate or target, general remarks, source of information, &c.	
	Lbs.		*Lbs.*	*Feet.*	*Feet.*	*Ft. tons.*	*Ft. tons.*	*Inches.*	*Inches.*		
.....	50	Palliser; chilled iron.	250	.....	1,420	3,496	402	11.4	.....	Shot all broke up. Of the first three shots one barely touched backing. Cracks superficial. Fourth, at center of previous triangle of impacts, broke the plate in two; fifth completed destruction of plate. (V., p. 476; E., 312.)	
.....	.....	....do	.....	.....	.....	.....	.....	.....	.....	An experiment. Chilled projectiles broke up on face, but when fired at back went clean through. (V., p. 478.)	
.....	50	....do	250	.....	1,420	3,496	.....	11.4	1½	Shot broke up. (V., p. 476; E., p. 312.)	
P	50	....do	250	1,421	1,420	3,496	388	11.4	.....	In no case reached iron. Cracks in steel alone. Projectiles broke up. Ogival head only penetrated. For Inflexible's turrets. (V., p. 480.)	
P	50	....do	250	.....	1,420	3,496	466	11.4	.....	First shot, no cracks; second, two cracks; and third, five more; all in steel. (T., p. 30.)	
..do	50	... do	257	about 1,460	.....	3,790	690	12	.....	Projectiles all broke up. Plate bulged at rear and cracked in steel face. Cracks in rear of impact No. 3. (*Engineer*, 11-6-1880.)	
..do	.....	....do	253.5	1,460	.....	3,746	.....	11.8	.....	Better results than with Inflexible's turret plate. (E., p. 373.)	
Cubical prism.	69.4	Krupp's steel and Finspong chilled iron.	402.6	1,426	1,411	5,556	about 1,041	14.22	Nearly complete.	1st. Krupp 15-centimeter steel. Point pierced rear face. No cracks.	*Le Yacht*, April 17, 1884. *Engineer*, May 30, 1884.
Brown prism.	42.9		112.4	1,765	1,742	2,326	450	11.6	.. do	2d. Armstrong 10-inch shell. Complete penetration. Projectile whole in rear.	
										3d. Armstrong 10-inch iron. Large pieces knocked off.	
.....	.....	....do	.....	.....	.....	.....	.....	.....	Slight ..	1st. Krupp 15-centimeter steel. A few radical and concentric cracks.	
									Complete	2d. Armstrong 10-inch steel. Large hole. Projectile found broken in rear.	
										3d. Armstrong 10-inch iron (tempered). Target destroyed.	
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1st. Krupp 15-centimeter steel. Penetration greater than above. A horizontal crack.	
										2d. Armstrong 10-inch steel. Same as with Cammell.	
										3d. Armstrong 10-inch iron. Large pieces knocked off.	
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1st. Krupp 15-centimeter steel. Vertical crack through impact.	
										2d. Armstrong 10-inch steel. Projectile broke up. Rear backing plate not pierced. Left-hand lower corner of target carried away through weakness of target frame.	
P	50	Compressed steel, Whitworth. Cast steel, Cammell.	268	.....	1,406	3,673	.....	11.8	10½	Considerable crack at back. Projectile much set up..	T., p. 32.
									Complete	Projectile broken up.....	
..do	31	Steel.....	80	1,785	1,755	1,708	.....	9.9	Nearly complete.	Head of projectile 8½ inches through plate.....	An experiment. (E., p. 344.)
..do	57	Palliser; chilled iron.	182.4	1,496	1,466	2,521	.....	10.8	...do	Head of projectile and most of body through plate.	
P	50	....do	270	.....	1,406	3,700	400	11.8	4.92 4.82 5.51	Projectiles broke away from heads; 1st and 3d slight, 2d serious cracks. (V., p 490; E., 376.) Similar plate ordered for H. M. S. *Conqueror*.	
..do	50	....do	270	.....	1,406	3,700	425	11.8	Maximum 6	Three shots. None pierced. One entered 6 inches and remained in plate. Others broke up. (T., p. 30.)	
P	50	Palliser; chilled iron.	260	.....	1,444 to 1,430	4,132 to 4,050	379	12.0	5.5	Seven radical cracks. One, 6½" deep, reaching to top of plate.	
.....	.....	.....	.....	.....	.....	.....	371	11.9	6.5	Five new cracks. Bulge at back 1".	
.....	.....	.....	.....	.....	.....	.....	.....	.....	6.9	Old cracks opened out. Piece of face knocked off.	
P	50	Steel; Cammell...	279	.....	1,405	3,822	351	11.8	6.7	Several new cracks. (.75 per cent. carbon.)	
P²	160	....do	840	....	1,425	11,824	1,085	17.8	Complete.	Plate broken through. A 20" disk forced into backing. Shot broke up inside of backing.	
P²	.....	Steel.....	840	.....	1,413	11,695	1,073	17.5	Complete	Struck near impact 4. Whole plate broken up. Backing pierced. Projectile broken up. (V., p. 495; *Engineer*, 8-9-82.)	

TABLE III.—MATERIAL, DIMENSIONS, WEIGHTS, &c., OF EXPERIMENTAL

Place and date.	Plate or target.									Gun.			
	Material and peculiarity.	Maker.	Length.	Breadth.	Thickness.	Weight.	Backing.	Bolts.	Distance from gun.	Nature.	Caliber.	Weight.	Length of bore.
					In.	*Tons.*			*Yds.*		*Inches.*	*Tons.*	*Cals.*
Nettle, Jan., 1882	Compound—3¾ steel, 7¼″ iron.	Cammell	8′ 0″	6′ 0″	11	9.8			10	Woolwich M. L. R.	9	12	14.8
Nettle, May, 1882										do	9	12	14.8
Nettle, May, 1882										do	10	12	14.6
Nettle, July, 1882	Compound	Brown	7′ 9″	5′10½″	11	9			10		9	12	14.8
											10	18	14.6
Shoeburyness, Oct., 1879.	Wrought iron				12		None			Armstrong M. L. R., chambered.	8	11½	26
	Do				12		do			do	8	11½	26
Ochta, 1882	Compound—4″ steel, 8″ iron.	Cammell	8′ 0″	7′ 0″	12	12¼	12″ wood, 3¼″ skin.	4	117	Russian B. L. R.	11	32	32
Do	Steel	Schneider	8′ 0″	7′ 0″	12	12¼	do	12	117	do	11	32	32
Shoeburyness, Aug., 1883.	Compound—4″ steel, 8″ iron.	Cammell	7′ 0″	7′ 0″	12	10.5	Granite		200	Woolwich M. L. R.	16	30	18
St. Chamond, Sept., 1883.	Compound; tapered from 11″.73 to 14″.64; ⅓ steel, ⅔ iron.	Ch. & Com.	8′ 0″	7′ 6″	*13.19	14.34	Solid wood	12 Schneider		French B. L. R., 27cm.	12.6	30	28.5
Shoeburyness, Oct., 1879.	Wrought iron				14					Armstrong M. L. R., chambered.	8	11½	26
Shoeburyness, 1880	4¼″ steel, 10″ iron; slightly convex.		7′ 7″	7′ 0″	14.25	13.2			100	Woolwich M. L. R.	12.5	38	15.8
Do	5″ steel, 11″ iron		7′ 7″	7′ 0″	16	14.2			100	do	12.5	38	15.8
Do	do		7′ 7″	7′ 0″	16	14.2			100	do	12.5	38	15.8
Shoeburyness, Aug., 1883.	Wrought iron; two 8″ plates, with 5″ wood between.				16		Granite			do	16	80	18
France, Aug., 1884	Compound—⅓ steel, ⅔ iron.	C. & C	14.96	8.66	16.15	31.68	Solid wood	12 Schneider		French B. L. R., 32cm.	12.6	38	19.2
Gavres, Apr., 1881	do	Cammell			17¾					do	12.6	38	19.2
Gâvres, July, 1881	Steel; tapered from 15″.75 to 19″.68.	Schneider	7.78	7.2	*17.7	18.4	Solid wood	Twelve 2¼″ Schneider.		French B. L. R., 32cm long; model 1870.	12.6	38	19.2

*Average.

ARMOR-PLATES OR TARGETS, WITH RESULTS OF TRIAL—Continued.

Powder.		Projectile.		Velocity.		Energy at impact.		Penetration.		
Kind.	Weight.	Class, material, and maker.	Weight.	At muzzle.	At impact.	Total smashing effect.	Per ton of weight of plate.	Calculated.	Actual.	Effects from impact and ultimate resistance of plate or target, general remarks, sources of information, &c.
	Lbs.		*Lbs.*	*Feet.*	*Feet.*	*Ft. tons.*	*Ft. tons.*	*Inches.*	*Inches.*	
P	50	Palliser; chilled iron.	258	.....	1,420	3,606	368	11.7	4.5	1. Five surface cracks... } Bulged at back of each impact. All projectiles broken. One crack 5".5 deep.
									5.0	2. Four surface cracks ..
									4.9	3. One surface crack .....
P	70	Palliser; chilled iron.	400	.....	1,364	about 5,164	527	13.6	4½	4. Two new cracks... } None of these cracks went below steel face. Bulges at back as before. (V., p. 495.) Pamphlet from Cammell & Co. Plate for H. M. S. Collingwood.
										5. Four new cracks ..
										6. Two new cracks...
										7. Four new cracks ..
	50		250	.....	1,420	3,496	388	11.5	3.7	No crack. (T., p. 31.)
									4.4	Several cracks.
									3.9	Do.
	70		400	.....	prob. 1,364	5,165	574	13.2	4.4	First shot indented 4.4. Several bad cracks. Depths not measured. Bulges at back, ¾" to ⅞", not opened. (V., p. 495.)
P	68	Palliser; chilled iron.	182.4	1,677	1,647	3,439	.....	12.1	.....	Practically through. } (E., p. 348.) Experimental firing.
P	65	Steel	182.4	1,660	1,630	3,368	.....	11.9	Complete	Projectile entire, but somewhat swelled. Plate broke in two.
	132	Chilled iron; Perm	553½	.....	1,506	8,704	711	16.3	5	Number of small face cracks. Projectile broke head in plate. Three bolts broken. Second shot forth bolt broke. Upper left-hand corner broken off. Third, new crack.
	81	Chilled iron	553½	.....	1,167	5,228	427	12.2	.....	
	81	....do	553½	.....	1,168	5,228	427	12.2	3.5	New face cracks. Part of steel face knocked off. Third and fourth shots at Cammell plate were at an angle of 12°. (T., p. 33, V., p. 491; Proc. R. A. Institution, Vol. XII, No. 7; Cammell & Co.'s pamphlet and photographs.)
	81	....do	553½	.....	1,167	5,228	427	12.2	.....	
	132	....do	553½	.....	1,506	8,704	711	16.3	13	Broke in five pieces, held together by bolts. Projectile broken.
	81	....do	553½	.....	1,165	5,228	427	12.2	16	Into 9 pieces. Projectile broke.
	81	Steel; Aboukoff	553½	.....	1,165	5,228	427	12.2	Complete	Nearly half the target knocked off. Projectile found uninjured 740 yards in rear. Same authority as above.
Pr	450	Palliser; chilled iron.	1,700	.....	about 1,600	about 30,000	about 2,857	25	.....	Shot broke up. Point just at face of granite. Plate still good. Capt. Orde Browne, R. A. (*Engineer*, 31-8-83.)
		Chilled iron; C. & C.	476	.....	1,384	6,320	448	14.2	7.4	Thickness at impact 12".67. Radial and concentric cracks. } Reception tests of plates for the "Caiman." Pamphlet and photographs from Chatillon & Commentry.
									4.4	Thickness at point of impact 12".67. Radial and concentric cracks. One radial crack extended to edge of plate.
									5.9	Thickness at impact 13".60. Previous cracks opened out. All the projectiles broke up.
P	88	Ogival; 2 cal.; forged steel.	182.4	1,969	1,972	4,915	.....	14.4	Complete	Shell broke into several pieces, plate into three. (E., p. 348.)
P²	160	Tempered	826.25	.....	1,435	11,800	894	17.8	Complete	Shell broke up. Broke up plate and got 12" into backing. 0.8 per cent. carbon. (Proc. R. E. I., Vol. XIV, No. 13.)
P²	180	....do	826.25	.....	1,473	12,460	877	18.2	10.5	Plate broke in two and badly cracked. Shell broke up. 0.5 per cent. carbon. (Proc. R. E. I., Vol. XIV, No. 13.)
P²	180	....do	826.25	.....	1,473	12,460	877	18.2	10.9	Plate broke in four or five pieces. Shell broke up. 0.8 per cent. carbon. Proc. R. E. I., Vol. XIV, No. 13.)
P	450	Palliser; chilled iron.	1,700	1,588	nea'ly 1,600	29,730	.....	25	Complete	Ten feet into granite backing. Capt. Orde Browne. (*Engineer*, 31-8-83.)
		Chilled iron; C. & C.	760	.....	1,332	347	295	15.8	4.9	Two cracks. Projectile broke. } Reception tests of plates for Formidable and Admiral Baudin. (Pamphlet and photograph. Chatillon & Commentry.)
			760	.....	1,332	.....	.....	.....	.....	Vertical split. Projectile broke.
			760	.....	1,332	.....	.....	.....	.....	Horizontal split. Projectile broke.
	150	Palliser; chilled iron.	759	.....	.....	.....	.....	.....	8	Two cracks; one from impact to edge of plate; other slight. (V., p. 486; T., p. 33.)
									9¾	Through crack extending to bottom; 8 surface cracks.
									15.9	Plate split, but held up by bolts. Reception tests.
	150	Chilled iron; C. & C.	760	.....	1,424	10,683	81	16.9	9.4	Three fine cracks started. Projectile broken up. (Reception tests Schneider pamph.)
	150	....do	760	.....	1,424	10,683	581	16.9	6.2	Old cracks extended through plate. Projectile broke up.
	101.5	....do	760	.....	1,493	11,743	638	17.7	3	Two new cracks; others extended. (Reception tests, Schneider pamph.)

TABLE III.—MATERIAL, DIMENSIONS, WEIGHTS, &c., OF EXPERIMENTAL

Place and date.	Plate or target.									Gun.			
	Material and peculiarity.	Maker.	Length.	Breadth.	Thickness.	Weight.	Backing.	Bolts.	Distance from gun.	Nature.	Caliber.	Weight.	Length of bore.
					In.	*Tons.*			*Yds.*		*Inches.*	*Tons.*	*Cals.*
Gavres, Dec., 1881 ..	Steel; from 15".81 to 19".68.	Schneider...	7.77	7.45	17.7	18.5	Solid wood....	Twelve 2½" Schneider.	.....	French B. L. R., 32cm long; model 1870.	12.6	.....	.....
Gavres, 1880.....	Steel; tapered 15".81 to 19".68; 4¾ steel.	... do	.....	.....	about 18	.....	.....	.....	.....	... do	12.6	38	19.2
St. Chamond, June, 1884.	Steel.....	....do	.....	.....	.....	.....	.....	.....	.....	French B. L. R., 34cm.	12.4	.....	.....
Shoeburyness, July, 1880.	Compound—5" steel, 13" iron.	Cammell....	9' 6"	9'00"	18	about 24	Heavy timber.	None	76	Woolwich M. L. R	12.5	38	15.8
Gavres, 1880.....	Cast-steel; oil-tempered.	Terre Noire.	(*)	(*)	(†)	14	Oak.....	Yes.....	87	French B. L. R., 32cm.	12.6	38	19.2
	Cast-steel; annealed..	....do	(*)	(*)	(†)	.....	.....	.....	.....	....do	.....	.....	.....
	Steel; hard	Schneider...	(*)	(*)	(†)	.....	.....	.....	.....	....do	.....	.....	.....
	Steel; soft.....	....do	(*)	(*)	(†)	.....	.....	.....	.....	....do	.....	.....	.....
	Compound—½ steel, ⅝ iron.	Cammell....	(*)	(*)	(†)	.....	.....	.....	.....	....do	.....	.....	.....
	Wrought iron; hard face.	Marrell.....	(*)	(*)	(†)	.....	.....	.....	.....	....do	.....	.....	.....
Aug., 1883	Wrought iron.....	.....	.....	.....	18	.....	(See remarks).	.....	90	Whitworth R. L. R.	9	20	29
Speria, Nov., 1882...	Compound—½ steel, ⅝ iron; 0.69 p. c. carbon.	Cammell....	10'10"	8' 7"	18.9	31.5	4' oak.....	6 of 4½"	.....	Armstrong M. L. R.	17.7	100	20.9
Speria, 1882.....	Compound; 0.70 p. c. carbon.	Brown	10'10"	8' 7"	18.9	31.5	....do	....do	.....	....do	17.7	100	20.9
Do.....	Steel; 0.45 p. c. carbon; oil-tempered to a depth of 6". Plate hammered down from 7'.	Schneider...	10'10"	8' 7"	18.9	31.5	....do	20 of 4½", screwed into back.	.....	.....	.....	.....	.....
Speria, Oct., 1884....	Compound—½ steel, ⅝ iron.	Cammell....	11' 8"	10' 0"	18.9	39.6	21" of wood on steel frame of ship.	18 Schneider..	108	Armstrong B. L. R.	17	102	20.6
										Do.....	10	26	30

* All about 6' 6" × 6' 6".

† 18" (average) tapered from 16" to 20".

ARMOR-PLATES OR TARGETS, WITH RESULTS OF TRIAL—Continued.

Powder.		Projectile.		Velocity.		Energy at impact.		Penetration.		Effects from impact and ultimate resistance of plate or target, general remarks, sources of information, &c.	
Kind.	Weight.	Class, material, and maker.	Weight.	At muzzle.	At impact.	Total smashing effect.	Per ton of weight of plate.	Calculated.	Actual.		
	Lbs.		*Lbs.*	*Feet.*	*Feet.*	*Ft. tons.*	*Ft. tons.*	*Inches.*	*Inches.*		
.....	148.6	Chilled iron; C.&C.	760	.....	1,434	10,834	585	17.0	4	No cracks; projectile broken.	
	148.6	....do	760	.....	1,434	10,834	585	17.0	8.9	Crack from left edge to impacts 2 and 1; maximum width, 0.2″.	
	160	....do	760	.....	1,499	11,838	640	17.7	8.8	Crack from hole 3 to top of plate, clear through plate. Fine cracks to 1 and 2. Projectile broken. No bolts broken. Backing uninjured. (Reception tests, Schneider pamphlet.)	
.....	.....	C. & C.	.....	1,496 to 1,434	.....	9,730 to 10,399	.....	.....	.....	Three shots fired. All broke up. First made 3 small cracks; others no new ones. For the *Terrible*. Plate too heavy for gun. (T., p. 33.)	
AA$\frac{23}{28}$	236	Hardened point; steel; C. & C.	926	.....	1,467	13,814	.....	18.6	7.5	Projectile broke up and head fell out. (Confidential document.)	
P[1]	180	Palliser; chilled iron.	828	1,516	1,504	12,545	541	18.6	.....	Projectile broke up. Slight penetration. Two horizontal cracks from impact. Plate suffered but little. Steel face scaled off to diameter of 16″. (T., p. 33. E., p. 374. Engineer, 28-9-83.)	
.....	160	Chilled iron; C.&C.	760	1,473	1,460	11,230	802	17.3	.....	Broke into 6 or 7 pieces. One shot entered backing.	Proc. R. E. I., vol. IV. No. 13.
				1,434	1,420	10,623	759	16.6	.....		
.....	.....	....do	.....	1,473	1,460	11,230	802	17.3	.....		
				1,434	1,420	10,623	759	16.6	.....		
.....	.....	....do	.....	1,473	1,460	11,230	802	17.3	.....	Broke into 2 or 3 pieces.	
				1,434	1,420	10,623	759	16.6	.....		
.....	.....	....do	.....	1,473	1,460	11,230	802	17.3	.....		
				1,434	1,420	10,623	759	16.6	.....		
.....	.....	....do	.....	1,473	1,460	11,230	802	17.3	.....	Broke in two first round. Stood others better.	
				1,434	1,420	10,623	759	16.6	.....		
.....	.....	....do	.....	1,473	1,460	11,230	802	17.3	.....	Broke into 3 pieces.	
				1,434	1,420	10,623	759	16.6	.....		
C, '82, bl'k priam.	197	Hexagonal; forged steel; Whitworth.	408	.....	1,900	10,017	.....	19.3	Complete.	Went through everything uninjured and buried itself 17 feet behind in sand. Backed up by a steel hoop 57″ long, filled with sand; 7″ oak, steel angles all well riveted. Cast-iron plate, 5″; balks of timber well bedded and covered with wet sand. (Official report.)	
Fossano ...	328.5	Gregorini; chilled iron.	2,000	.....	1,219	20,600	666	19.33	6.9	Head buried. Plate racked. Corner detached.	Proc. R. A., I, vol. xii, No. 7; Esperienze Fatte, p. 5, v, p. 498. T., p. 38;
	478.3	....do	2,000	1,573	1,565	33,960	1,070	24.7	8	Plate broke into four or five pieces, and fell from bolts. Backing badly racked. All bolts drawn or snapped. Plate bulged in rear of impact.	
.....	328.5	....do	2,000	.....	1,223	20,710	657	17.8	3	Effect less than on Cammell plate.	
	478	....do	2,000	1,568	1,564	33,910	1,076	25.2	8	One corner held. Rest fell down in six pieces. Penetration appeared slight. Backing badly racked and broken. All bolts but two snapped or drawn.	
.....	328.5	....do	2,000	.....	1,232	21,050	668	19.9	8.25	Head of shot buried. No signs of weakness of plate or bolts.	
	478.3	....do	2,000	.....	1,545	33,100	1,051	24.8	9.25	Deep cracks. Vertical split .9″ wide, tapering to .7″. Back of target stood well. No bolts broken.	
	478.3	Steel; *Terre Noire*.	2,078	1,546.5	1,538	34,080	1,080	25.2	12.5	Projectile flattened and bounded back. Part of plate driven into backing and part down. Fracture, fibrous. Shot set up from 44″.5 to 28″. Backing rent and split.	
	478	San Vito; cast-steel.	2,124	.....	1,512	33,670	1,069	25	Complete.	Projectile broke up, but passed through plate and backing.	
Fossano; progressive, 2 gr's to the pound.	772	Cylindo-ogival; steel; Krupp.	1,841	1,883	1,870	44,660	1,128	*28.3 †29.3 ‡30.6	Complete	Line of fire 4° from normal. Projectile broke up. Plate split into six parts; many cracks.	Italian official report, Le Yacht, Nov. 15 and Dec. 9, 1884; Official documents; *Engineering*, Oct. 24, 1884.
		Steel; Krupp	470	.....	2,149	15,047	380	22.4	.....	Piece fell off exposing backing. About 5 tons metal down.	
		....do	470	.....	2,136	14,865	375	22.2	.....	Part struck broken into 7. Two large pieces driven through to rear. Target ruined.	

* Muggiano formula. † Maitland's formula. ‡ Krupp's formula.

TABLE III.—MATERIAL, DIMENSIONS, WEIGHTS, &c., OF EXPERIMENTAL

Place and date.	Plate or target.									Gun.			
	Material and peculiarity.	Maker.	Length.	Breadth.	Thickness.	Weight.	Backing.	Bolts.	Distance from gun.	Nature.	Caliber.	Weight.	Length of bore.
					In.	*Tons.*			*Yds.*		*Inches.*	*Tons.*	*Cals.*
Spezia, 1884	Compound—½ steel, ½ iron.	Brown	11′8″	10′0″	18.9	39.6	(See foregoing)	18 Schneider	108	Armstrong B. L. R.	17	102	20.6
										Do	10	26	30
											10	26	30
Do	Steel	Schneider	11′8″	10′0″	18.9	40.2		do	108	do	17	102	20.6
										Do	10	26	30
										Do	10	26	30
										Do	10	26	30
										Do	10	26	30
Shoeburyness, 1884	Compound—½ steel, ½ iron.	Cammell	10′8″	9′0″	19	33	(See remarks)	16		Woolwich M. L. R.	16	80	18
Spezia, 1876	Steel; solid	Schneider	12′0″	4′8″	22	22.8	do		100	Armstrong M. L. R.	17	100	20.6
	Wrought iron; solid	Cammell	12′0″	4′8″	22	22.1	do		100	do	17	100	20.6
	Do	Marrel	12′0″	4′8″	22	22.1	do		100	do	17	100	20.6
	Wrought iron; 12″ iron, 12″ wood, 10″ iron, 16″ wood.	do	12′0″	4′8″	22	22.1	do		100	do	17	100	20.6
	Do	Cammell	12′0″	4′8″	22	22.1	do		100	do	17	100	20.6
	Wrought iron; solid	Brown	12′0″	4′8″	22	22.1	do		100	do	17	100	20.6
	Wrought iron and Gregorini chilled iron; 8″ iron, 12″ wood, 14″ Gregorini chilled.	Marrel	12′0″	4′8″	22	21.2	do		100	do	17	100	20.6
	Cast iron; 8″ and 14″	do	12′0″	4′8″	22	21.2	do		100	do	17	100	20.6
	Wrought iron; solid	Brown	12′0″	4′8″	22	22.1	do		100	do	17	100	20.6
	Steel	Schneider	12′0″	4′8″	22	22.4	do		100	do	10	18	14.6
											10	18	14.6
											11	25	13.2
	Wrought iron; solid	Cammell	12′0″	4′8″	22	22.1			100	do	10	18	14.6
											10	18	14.6
											11	25	13.2
	Do	Marrel	12′0″	4′8″	22	22.1	(See remarks)			do	10	18	14.6
										Do	10	18	14.6
										Do	11	25	13.2
	Wrought iron; 12″ iron, 10″ wood, 10″ iron.	Cammell	12′0″	4′8″	22	22.1				do	10	18	14.6
										Do	10	18	14.6
										Do	11	25	13.2
	Do	Marrel	12′0″	4′8″	22	22.1				do	10	18	14.6
										Do	10	18	14.6
										Do	11	26	13.2

ARMOR-PLATES OR TARGETS, WITH RESULTS OF TRIAL—Continued.

Powder.		Projectile.		Velocity.		Energy at impact.		Penetration.		Effects from impact and ultimate resistance of plate or target, general remarks, sources of information, &c.
Kind.	Weight.	Class, material, and maker.	Weight.	At muzzle.	At impact.	Total smashing effect.	Per ton of weight of plate.	Calculated.	Actual.	
	Lbs.		*Lbs.*	*Feet.*	*Feet.*	*Ft. tons.*	*Ft. tons.*	*Inches.*	*Inches.*	
Progressive, 2 gr's to the pound.	772	Steel; Krupp	1,841	1,872	1,860	44,164	1,116	*28.1 †29.2 ‡30.2	Complete	Line of fire 4° from normal. Projectile broke up. Plate split into four pieces. Many radial and one heavy concentric crack. Corresponding steel face off to a diameter of 63″ into small pieces. Back of plate more injured than Cammell's. (Showed bad weld between steel and iron.)
			470		2,159	15,187	383	22.5	12.7	One-third of plate knocked off exposing backing. The latter badly damaged. Projectile broke up.
			470		2,168	15,314	387	22.5	14	Projectile broke. ⅓ plate down. Bolts broken and thrown to rear. Abandoned contest.
	772	Steel; Krupp	1,841	1,873	1,860	44,183	1,099	*28.1 †29.2 ‡30.2	Complete	Line of fire 4° from normal. Projectile broke up. Plate split into three pieces. No other serious cracks. (Head of shot passed on with an estimated velocity of 886 f. s.).
			470		2,168	15,314	381	22.5	9	Four large cracks. Projectile broke. Head in plate. Back of target and bolts intact.
			470		2,172	15,370	38	22.6	11.4	New crack. Projectile broke. Head in plate. Piece 3 square feet knocked out of edge. Back elsewhere sound.
			470		2,159	15,187	378	22.5	10.8	Four new cracks. Projectile as before.
			470		2,152	15,088	375	22.4	10.6	Two pieces from bottom of plate detached. One bolt gone. It is said that the projectiles were more broken than by English plates.
Prism	450	Palliser; chilled iron.	1,700		1,600	30,100	912	25	8 to 9	Plate in five pieces. Projectile broken up. 13 bolts gone. All the pieces except one would have fallen from side of ship at sea. Frames all gone but one. Whole structure driven back 8″. Plate bulged in 7″. Excellent fracture and manufacture. (Backing represented side of Admiral class of ships R. N. with some minor exceptions. Backing not sufficiently rigid.—Official letter.)
Waltham Abbey; cubical.	341	Gregorini; chilled iron.	2,000	1,475	1,463	29,370	1,311	24	22	Framing dangerously bulged and torn. Plate wrecked.
	341	do	2,000	1,480	1,469	29,640	1,341	24.1	Complete	Half the plate shot away. This shot got through with 650 f. s. velocity, or 5,500 f. t. remaining. Hole 4′ diam.
do	341	do	2,000	1,502	1,490	30,485	1,379	24.5	do	Destroyed plate. Shot passed through large hole.
do	341	do	2,000	1,492	1,480	30,050	1,360	24.3	do	This target had been previously attacked by 10″ and 11″ guns. It was utterly destroyed. Main part carried off by shot.
Fossano; progressive	240	do	2,000	1,050	1,043	15,180	687	17.2	18.8	Shot passed through front plate and split it from top to bottom. Iron skin cracked, and beam behind doubled up.
do	240	do	2,000	1,063	1,063	15,500	701	17.6		Plate hit at lower edge, and pieces broken off.
do	400	Gregorini; chilled iron.	2,000	1,494	1,483	30,500	1,439	24.4	Complete	Utter ruin of plate.
do	400	do	2,000	1,502	1,489	30,782	1,452	24.5	do	Utter ruin of plate.
do	240	do	2,000	1,062	1,046	15,200	688	17.3	15.6	Shot broke up. Head remained in hole.
do	400	do	2,000	1,499	1,486	30,647	1,387	24.4	Complete	Large portion of plate torn off. Rear so ruined as to be beyond repair.
W. A. cub.	264	do	2,000	1,299	1,289	22,950	1,039	21.2	do	Shell just passed through plate, tore off a large piece and split the plate from top to bottom. Backing not pierced.
Fossano; progressive	77.2	do	397	1,401	1,388	5,269	235	13.4	10	At first, little damage. Soon split along two cracks. Shell broke.
do	77.2	do	397		1,398	5,537	501		13	A salvo of 10″ and 11″ guns. Large piece dislodged. Plate suffered severely.
do	94.6	do	531		1,260	5,677			13	
do	77.2	do	397	1,441	1,431	5,269	239	13.8	10.8	Two cracks developed.
do	77.2		531		1,398	5,537	508		18	Salvo. 11″ shot broke up. Entire plate driven back.
do	94.6		397		1,260	5,677			13	Entire plate driven back an inch and cracked. Frame shaken.
do	77.2	Gregorini; chilled iron.	397	1,411	1,398	5,269	239	13.5	11	Crack from bolt-hole.
do	77.2	do	397						12.5	Salvo. Dislodged a huge mass and cracked the remainder.
do	94.6	do	531						14.5	
do	77.2	do	397	1,399	1,386	5,130	234	13.4	13	
do	77.2	do	397	1,415	1,402	5,328				Salvo. Both projectiles pierced front plate and 2″.4 into rear plate. Dislodged a corner of the plate.
do	94.6	do	531	1,316						
do	77.2	do	397	1,427	1,415	5,431	246	13.6	10	Split the plate in several directions; some pieces nearly detached.
do	77.2	do	397	1,398	1,387	5,150	490			Salvo. 10″ shell through front plate and 1″ into wood; 11″ shell 2″ into rear plate. Front plate much cracked. Pieces detached. Wide fissures opened.
do	94.6	do	531	1,259	1,249	5,677				

Backing 28″.8 wood, 1½ iron against a frame of a ship; T., pp. 18, 21.

T., pp. 18, 21. E., p. 360.

* Muggiano formula. † Maitland's formula. ‡ Krupp's formula.

TABLE III.—MATERIAL, DIMENSIONS, WEIGHTS, &c., OF EXPERIMENTAL

Date and place.	Plate or target.									Gun.			
	Material and peculiarity.	Maker.	Length.	Breadth.	Thickness.	Weight.	Backing.	Bolts.	Distance from gun.	Nature.	Caliber.	Weight.	Length of bore.
					In.	*Tons.*			*Yds.*		*Inches.*	*Tons.*	*Cals.*
Spezia, June, 1879...	Cast-steel, covered by a 1″ iron plate.	Terre Noire.	9′	4′8″	27.56	20.8	20″ oak, braced	None	125	Armstrong chambered M. L. R.	17.72	100	.....
			9′	4′8″	27.56	20.8	... do	....do	125	... do	17.72	100	.....
			9′	4′8″	27.56	20.8	....do	....do	125	....do	17.72	100	.....
Shœburyness, Feb., 1877.	Wrought iron; four 8″ plates with 5″ wood between.	Brown	16′0″	10′0″	32	92	15″ teak	3 between each pair of plates.	120	Woolwich M.L. R., unchambered.	16	81	18
Shœburyness, May, 1877.	Same target	.....	.....	.....	.....	.....	.....	.....	.....	Woolwich M.L. R., chambered.	16	81	18
Buckan, Oct., 1883 ..	Gruson chilled iron curved. Between 2 side plates with a cover plate forms ½ a ton.	.....	.....	.....	47	46¾	Iron plates and masonry piers.	.....	27	Krupp	12	.....	25
											12	.....	.....
											12	.....	.....
Buckan, May, 1884..	Gruson chilled iron cover plate.	.....	.....	.....	Variable back, 12.8	47	.....	.....	30	....do	12	.....	25
											12	.....	.....
											12	.....	.....
											12	.....	.....
											12	.....	.....
											12	.....	.....

The figures and letters in **black type** are supplied by the compilers, and are only probably correct where they apply to types of guns.

ARMOR-PLATES OR TARGETS WITH RESULTS OF TRIAL—Continued.

Powder.		Projectile.		Velocity.		Energy at impact.		Penetration.		Effects from impact and ultimate resistance of plate or target, general remarks, sources of information, &c.
Kind.	Weight.	Class, material, and maker.	Weight.	At muzzle.	At impact.	Total smashing effect.	Per ton of weight of plate.	Calculated.	Actual.	
	Lbs.		*Lbs.*	*Feet.*	*Feet.*	*Ft. tons.*	*Ft. tons.*	*Inches.*	*Inches.*	
Fossano; progressive.	550	Gregorini; chilled iron.	2,022	1,715	1,702	Muzzle 41,241	Muzzle 1,982	27.5	14	Shot rebounded and broke into 200 pieces. Broke off ⅓ plate. (T., p. 21; Eng., Patte, p. 6; E., p. 360; V., p. 430; *Engineering*, 22-5-79.)
...do	550	Compressed steel; Whitworth.	2,110	1,673	1,660	40,966	1,969	27.4	Complete	Tore off ⅓ plate. Shot slightly swelled in ogive.
...do	550	Forged steel; Armstrong.	1,946	1,736	1,723	40,653	1,950	27.3	11.8	Shot fell deformed in front of target. Plate completely broken. Abandoned trials. Three shots were to have been fired against each plate.
Cubical 1".5.	370	Palliser; chilled iron.	1,700	1,510	1,496	26,400	287	23.3	25" iron...	Head of projectile entire in hole. Body broken. Pierced 3 front plates and touched rear plate. (T., p. 22; Engineer, Feb., 1877; E., p. 290). Line of fire 1° 30' from normal. Shot turned 2° 30" to left and 2° down.
Cubical 1".5, central ignition.	425	....do	1,700	1,600	1,585	29,615	32.2	24.74	26" iron..	Point of shell visible through large cracks in target 2½" wide in place; 5" iron still in advance of shot, but fissured and opened in a star crack. Rear plate bulged 14".
Prism.....	264	Long, 3½ caliber harder steel, Krupp.	980	.....	1,460	14,498	.....	.....	Slight.....	Plate cracked clear across. Projectile splashed and welded to chill iron. (Eng., April 4, 1884).
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	More cracks. Plate not sufficiently braced.
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Broke plate into six parts.
P.P	176	Long, 3½ caliber harder steel, Krupp.	989	.....	1,132	8,718	.....	.....	.....	Cracks. Projectile broke up. (Eng., October 17, 1884.)
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Cracks. Projectile broke up.
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Cracks extending through plate. Projectile shattered.
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Cracks. Projectile shattered.
.....	.....	Flat head, harder steel, Krupp; diameter, 5.38.	.....	.....	.....	.....	.....	.....	.....	Oblong dent. Three cracks through. Projectile shattered.
.....	.....	....do	.....	.....	.....	.....	.....	.....	.....	Oblong depression. Former cracks lengthened.

conditions of experimentation, &c. Where they are mere computations based on authentic data they may be accepted as trustworthy.

TABLE IV.—SHOWING THE ACTUAL PENETRATION OF RIFLED

Place and date.	Butt or target.									Gun.			
	Material and peculiarity.	Maker.	Length.	Breadth.	Thickness.	Weight per cubic foot.	Backing.	Bolts.	Distance from gun.	Nature.	Caliber.	Weight.	Length of bore.
			Feet.	*Feet.*	*Feet.*	*Lbs.*			*Yds.*		*Inches.*	*Tons.*	*Cals.*
Dungeness, 1881	Concrete; 6 parts shingle, 1 sand, 1 part concrete.		39	12	31	138			145	Woolwich M. L. R.	10	18	
									145	do	10	18	
									145	B. L. R.	6	4	
									145	do	6	4	
									145	M. L. R	6.6	3½	
									145	do	6.6	3½	
									145	do	10	18	
									145	B. L. R.	6	4	
									145	M. L. R	6.6	3½	
	Earth; earth was loamy clay, chalk, stones, and bricks.		84	8	48				195	M. L. R	10	18	
	Earth									B. L. R.	6	4	
	Sand									do			
	Earth									M. L. R	6.6	3½	
	do									do	6.6	3½	
	Sand									do	6.6		
Shoeburyness, Aug., 1883.	Concrete, granite and concrete, broken granite.								200	do		80	
Spezia, May, 1880	Sand									Armstrong B. L. R.	17.7	100	
Spezia, Mar., 1881	Soft rock and sand								437				
Do							Rock						
Shoeburyness, 1865	Stiff marsh clay			14	45						10†		
											9.22		
Calais	Clay bank; ½ sand, ½ clay.			13.8					1,100		9.62		
Shoeburyness and Newhaven.	Earth										12		
Do											10		
Do											9		
Do	Concrete										12		
Do											10		
Do											9		
Do	Brick										12		
Do											10		
Do											9		
Do	Stone masonry										12		
											10		
											9		

CANNON INTO EARTH, GRANITE, CONCRETE, &c.

Powder.		Projectile.		Velocity.		Energy at impact.		Penetration.		
Kind.	Weight.	Class, material, and maker.	Weight.	At muzzle.	At impact.	Total smashing effect.	Per ton of weight of plate.	Calculated.	Actual.	Effect from impact and ultimate resistance of plate or target, general remarks, sources of information, &c.
	Lbs.		*Lbs.*	*Feet.*	*Feet.*	*Ft. tons.*	*Ft. tons.*	*Inches.*	*Ft. In.*	
P_2	95	Battering; chilled iron; Palliser.	408	1,446	1,424	5,738			17	The majority of the shells exhibited a tendency to turn to the right in the butt. None of the Pallisers broke up, nor, when filled with powder, did they burst. Common shell, 10″, neither broke up nor burst. A common shell, 6″, entered 10′ 9″ and then rebounded clear out of the butt. The tunnels made were much greater in diameter than the shell. The shells fired for penetration in this series were weighted and plugged. (Proc. B. D. Inst., Vol. XIII, No. 5.)
P_2	95	Common shell; cast iron.	408	1,446	1,424	5,738			13 10	
P	34	Palliser; chilled iron.	80	1,944	1,893	1,989			12 7	
P	34	Common shell; cast iron.	80	1,944	1,893	1,989			10 9	
P	25	Palliser; chilled iron.	100	1,509	1,497	1,555			8 2	
P	25	Common shell; cast iron.	100	1,509	1,497	1,555			8 5	
P_2	95	....do	408	1,446	1,424	5,738			8 9	To point of burst. Bursting charge, 20¼ lbs. Formed large craters 10′ to 14′ in diameter, and threw down large masses of concrete. Fitted with direct-action quick fuze.
P	34	....do	80	1,944	1,893	1,989			5 9	To point of burst. Fitted with direct-action quick fuze.
P	25	....do	100	1,509	1,497	1,555			4 7	Do.
P_2	95	....do	408		1,416				34 6	Concluded that common shell and quick fuzes give best results for smaller calibers and delayed action for larger.
		Palliser	408		1,416					All rose out of butt as did both common and Palliser out of sand. Butt too low.
P	34	....do	80		1,875					All broke up as did common shell, and in both earth and sand.
		....do	80		1,875				12 3½	
P	25	... do	100		1,452				14	One round. Penetration into sand appeared considerably less than into earth. All but one projectile in sand had turned completely around.
P	25	Common	100		1,452				14 6	
		....do	100		1,452				11	
	450	Palliser; chilled iron.	1,700		1,586	30,000			34	Formed a tunnel 2′ 3″ in diameter. (Eng., 28-9-83.)
			2,200	1,512					39 37 to 46	Three shots went beyond into rock another foot. (T. B., 45.)
									20	
									18 7	
			2,204							
					1,458				42 9	Through sand to rock. (Records of Engineer Board, New York.)
									43 4	Through sand to rock and 12″ into rock. (Records of Engineer Board, New York.)
									45 2	Through sand. (Records of Engineer Board, New York.)
									36 5 to 50	Mean of 23 shots.
									32 to 40	Mean of 43 shots.
			397		1,329				26 2	*Aide Memoire d'Artillerie.*
									50	*Aide Memoire R. E., p.* 304.
									45	
									40	
									15	
									14	
									12	
									15	
									14	
									12	
									10	
									9	
									8	

TABLE V.—TABLE SHOWING THE CALCULATED PENETRATIONS OF RIFLED CANNON INTO CLAY, SAND, AND GRANITE.

Krupp's B. L. cannon.	Caliber.	Weight.	Total length.	Length of bore.	Powder, weight of charge.	Projectile, weight of.	Initial velocity.	* Calculated penetrations.											
								At muzzle.			At 1,000 yards.			At 2,000 yards.			At 3,500 yards.		
								Heavy clay.	Sand mixed with gravel.	Granite.	Heavy clay.	Sand mixed with gravel.	Granite.	Heavy clay.	Sand mixed with gravel.	Granite.	Heavy clay.	Sand mixed with gravel.	Granite.
	Inches.	*Tons.*	*Feet.*	*Caliber.*	*Pounds*	*Pounds*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
40cm gun, 35-calibers length (under fabrication for Italian navy)	15.75	108 119	45.9	32 31.7	750 615	2,240 1,632	1,835 2,017	85.5 69.1	51.1 40.9	10.2 8.2	82.5 64.8	48.9 38.4	9.7 7.6	78.6 60.9	46.5 36.1	9.3 7.2	73.2 55.3	43.3 32.8	8.7 6.6
40cm gun, 25-calibers length	15.75	71	32.8	21.78	462	1,762	1,695	62.2	37.2	7.5	59.1	34.9	7.0	55.5	32.8	6.6	48.1	28.3	5.7
35.5cm gun, 35-calibers length	13.98	75.3	40.7	31.7	520 462	1,560 1,155	1,835 1,985	76.2 71.0	45.1 36.1	9.0 7.2	72.3 57.0	42.9 33.7	8.5 6.7	68.5 53.1	40.6 31.5	8.1 6.3	63.3 47.5	37.5 28.2	7.5 5.5
35.5cm gun, 25-calibers length	13.98	51.1	29.1	21.8	297	1,155	1,617	49.8	29.4	5.8	46.2	27.4	5.4	42.9	25.5	5.1	38.4	22.8	4.5
30.5cm gun, 35-calibers length	12.00	48	35.1	32	357	1,003	1,857	67.2	39.9	7.9	63.3	37.5	7.5	59.5	35.2	7.0	54.1	32.1	6.3
28cm gun, 35-calibers length	11.024	37	32.2	32	253	760	1,837	59.8	35.4	7.0	55.8	33.1	6.6	52.2	30.9	6.1	46.9	28.5	5.5
26cm gun, 35-calibers length	10.24	27.2	29.9	32	183	614	1,768	53.8	31.9	6.4	50.1	29.7	6.0	46.5	27.6	5.5	41.5	24.6	4.9
24cm gun, 35-calibers length	9.45	20.5	27.6	32	150	476	1,791	49.6	29.4	5.8	45.9	27.1	5.0	42.3	25.0	5.0	37.3	22.0	4.3
24cm gun, 30-calibers length	9.45	18.9	23.6	27	150	476	1,726	47.8	28.3	5.7	44.1	26.1	5.2	40.6	24.1	4.8	36.0	21.3	4.2
21cm gun, 35-calibers length	8.24	13.3	24	32	99	310	1,808	43.0	25.5	5.1	39.1	23.2	4.6	35.5	21.1	4.2	30.9	18.3	3.6
17cm gun, 30-calibers length	6.7	7	16.7	27	57	172	1,772	35.4	21.0	4.2	31.6	18.7	3.7	28.2	16.6	3.3	23.8	14.2	2.7
15cm gun, 35-calibers length	5.87	4.7	17.1	32	37.4 39.6	113 111	1,773 1,827	30.1 30.6	17.8 18.1	3.6 3.6	26.5 26.5	15.7 15.8	3.1 3.1	23.2 23.4	13.7 13.8	2.7 2.7	19.3 19.3	11.4 11.4	2.2 2.2

* The above computations were made by Lieut. F. E. Hobbs, Ordnance Department, U. S. A., from General Froloff's formula. Ordnance Notes No. 295. In calculating the penetration into granite a mean of General Froloff's constants (p. 17, Ord. Note No. 295) is taken, or A = 135.

NOTE.—The Italian 100-ton gun—cast iron hooped with steel—firing a projectile of 2,205 pounds with a striking velocity of 1,495 feet, penetrated from 39 feet to 46 feet into the sand firing butt (Ordnance Notes No. 174); the computed penetration by General Froloff's formula into sand mixed with gravel for the same velocity and weight of shot is 324 feet.

TABLE VI.—ARMOR-PLATED REVOLVING TURRETS (CHILLED CAST IRON) PREPARED AND IN CONSTRUCTION AT THE GRUSON WORKS ON THE ACCOUNT OF VARIOUS COUNTRIES.

[Extract from "*Giornale di Artiglieria e Genio*," 1883.]

Country.	Cannon mounted in turret.					Principal dimensions of turret.								Vertical firing sector.	Armor-plating.								Weight of the cupola.	Weight of the front armor.	Number of men required for the rotation.	Time required for an entire revolution, employing—	
	Caliber.		Length.	Weight.	Number per turret.	Interior diameter of drum.		Maximum exterior diameter of cupola.		Maximum interior height above maneuvering plane.		Interval between directrices of embrasures.			Maximum thickness of embrasure plate.		Maximum thickness of reverse plate.		Thickness of covering at the edge.		Minimum thickness of covering.					Men.	Steam-engine.
	Cm.	*In.*	*Cals.*	*Tons*		*M.*	*Ft.*	*M.*	*Ft.*	*M.*	*Ft.*	*M.*	*Ft.*	*Degrees.*	*Cm.*	*In.*	*Cm.*	*In.*	*Cm.*	*In.*	*Cm.*	*In.*	*Tons.*	*Tons.*		*Minutes*	*Minutes*
(1) Austria	12	4.7	26.5	1.7	2	4.2	13.7	5.1	16.7	2.1	6.8	1.6	5.2	{+25 / −10}	53	20.8	45	17.7	29	11.4	24	9.4	86	55	3 to 4	1.5	.....
(2) Austria	28	11.0	35	37.3	2	9.2	30.1	11.4	37.4	2.8	9.1	2.6	8.5	{+10 / −5}	110	43.3	100	39.3	45	17.7	30	11.8	694	360	10	15	2.5
(3) Italy	12	4.7	.....	.....	2	4.3	14.1	5.2	17.0	2.1	6.8	1.6	5.2	{+20 / −14}	53	20.8	45	17.7	29	11.4	24	9.4	89	74	4	1.5	.....
(4) Germany ...	15	5.9	22	3.5	2	5.2	17.0	6.1	20.0	2.9	9.5	1.7	5.5	{+25 / −5}	54	21.2	42	16.5	10	3.9	10	3.9	100	100	4	2	.....
(5) Germany ...	15	5.9	22	3.5	2	5.0	16.4	6.4	20.9	2.8	9.1	1.7	5.5	{+25 / −5}	70	27.5	65	25.6	30	11.8	20	7.8	165	70	4	6	.....
(6) Germany ...	28	11.0	22	27	1	7.4	24.2	8.9	29.2	3.9	12.7	....	....	{+12½ / −5}	77	30.3	70	27.5	32	12.6	20	7.8	310	100	10	6	.....
(7) Germany ...	28	11.0	22	27	2	8.3	27.2	9.6	31.4	3.9	12.7	2.2	7.2	{+12½ / −5}	85	33.4	70	27.5	32	12.6	20	7.8	350	120	10	16	4
(8) Holland	30.5	11.8	25	38.5	2	8.4	27.5	12.5	41.0	2.8	9.1	2.6	8.5	{+12 / −6}	110	43.3	100	39.3	50	19.6	30	11.8	595	305	10	12	2.5

(1) The carriages are furnished with wheels. The front armor, for a sector of 120°, corresponding to a corridor underneath, has less depth. To this sector corresponds externally a mound of earth upon the glacis.

(2) It is unprovided with permanent apparatus for the armament of the turret. Two accumulators serve for maneuvering the cannon upon the carriage. Steam-engine for the rotation. For rotation by hand a winch is employed.

(3) Horizontal firing sector, 360°. The corridor is covered with two sally-port plates. The sub-carriages are provided with wheels.

(4) Sub-carriages with wheels. Covering plate of forged iron. Behind the inner aperture of the embrasures there is a "*parapallottole*" of rolled steel, sustained by a net of thick cord.

(5) Sub-carriages with wheels. Front armor extending for a sector of only 210°. Covering plate in one single piece. Vertical winch for the rotation.

(6) Sub-carriages with wheels. Front armor extending for a sector of only 210°. Covering plate of old construction. Vertical winch for the rotation.

(7) Sub-carriages with wheels. Front armor extending for a sector of only 210°. Covering plate of old construction. Hydraulic machine for the rotation. Vertical winch for rotation by hand.

The embrasures of old construction are less contracted with respect to the chase of the pieces than those of the turrets constructed for other countries.

(8) Is furnished with permanent apparatus for the armament of the turret. Two accumulators serve to work the latter and to maneuver the cannon upon the carriage.

APPENDIX TO REPORT OF COMMITTEE No. 1.

REPORT OF THE COMMITTEE TO COLLECT INFORMATION AND REPORT UPON TORPEDOES, STATIONARY AND MOVABLE, AND TORPEDO BOATS.

COMMITTEE No. 2.

Lieut. Col. Henry L. Abbot, Corps of Engineers, Chairman.
Commander W. T. Sampson, U. S. N.

SYNOPSIS OF DATA.

(A) SUBMARINE MINES..... Classification. Application. Description. Requirements.

(B) MOVABLE TORPEDOES.. Function in Coast Defense. Sims Torpedo. Lay Torpedo. Weeks Rocket Torpedo. Howell Torpedo. Whitehead Torpedo.

(C) TORPEDO BOATS.

(A) SUBMARINE MINES, OR STATIONARY TORPEDOES.

CLASSIFICATION.

The function of submarine mines is to obstruct the channels leading to great military and naval establishments, to harbors of refuge for the commercial marine, to important cities, and to other points on the sea-coast where, without landing, an enemy could inflict serious damage or compel the payment of large sums to purchase immunity from bombardment. It is now universally admitted that without such auxiliary obstructions no sea-coast armament can give the needful security. Modern ships of war, with their high speed and heavy armor, can pass any shore battery which the art of man can erect, provided the channel be clear.

Submarine mines in respect to ignition are either self-acting or under control from the shore. The former, once in position, close the channel to friends and foes alike; the latter allow friendly vessels to pass in safety, but bar the way to hostile ships. For nations which have not abandoned the ocean, self-acting mines can only be used in exceptional locations, while mines under control are everywhere applicable.

Submarine mines in respect to depth of submergence are either buoyant or ground. The former are used in deep water, where to avoid excessive charges it is needful to float the explosive to a point near the hull. Ground mines rest upon the bottom in shallow water, where vessels passing over them must come within their destructive range.

In the United States service self-acting mines and mines under control are identical in pattern, differing only in the igniting arrangements.

Buoyant mines are spherical cases of open-hearth steel, provided with an excess of flotation and containing the charge and the igniting mechanism. They are held down by cast-iron mushroom anchors, attached by wire rope of suitable length to retain them below the water surface at all stages of the tide.

Ground mines are spherical segments of cast or wrought iron, containing the explosive and resting upon the bottom. Above them and below the water surface float buoys containing mechanism for igniting the charge when struck by passing vessels.

These two parts of the normal ground mine are connected by wire rope of suitable length. If the explosion is only to be effected by the act of an operator on shore, the buoy is omitted.

APPLICATION.

In disposing mines to obstruct our channels, the principle has been adopted that the whole area swept by the close fire of the forts must be rendered dangerous. It is not enough that one or more *lines* shall be occupied, because by countermining, or by sacrificing a few vessels, such a barrier may always be forced without much loss of time. By compelling the enemy to extend his operations over 4 or 5 miles of channel, all the time under a heavy fire of modern guns, and exposed to attack by movable torpedoes operated and controlled from shore stations, the attack becomes very difficult. The principal harbors of the United States have been carefully studied by the Board of Engineers; and projects based upon this principle, showing the proposed locations for the mines, are now on file in the Engineer Department in Washington, where they may be consulted.

DESCRIPTION.

The following details sufficiently explain the methods adopted by the principal maritime nations of the world at the present day. By common consent, and for obvious reasons, all possible mystery is thrown over this subject.

Self-acting mines.—Used for closing channels not needed for our own use. Such mines are dangerous alike to friends and foes. The cases were formerly improvised—often from wooden kegs, but they are now usually of wrought iron or steel, containing about 100 pounds of gun-cotton or dynamite. They are held down by a single mushroom anchor attached by a wire rope, and have sufficient flotation to remain nearly vertically over it when exposed to the strongest tidal currents of the harbor to be defended. They differ greatly in the mode of ignition. Sometimes this is purely mechanical, one pattern containing a very sensitive priming, which is ignited by the pressure transferred to it through a thin cap of copper or lead when struck by a vessel. Another pattern contains a mixture of potassium chlorate and sugar around a glass tube filled with sulphuric acid; the latter is broken by the shock of the contact, and the acid ignites the priming, which in turn fires a train of gunpowder leading to the charge. A recent form, known as the Russian or German mine, is provided with projections like horns, containing potassium bichromate in glass tubes; when one of the

latter is broken by the vessel, the fluid flows into a lower compartment of the plug containing the plates of a voltaic battery; the battery thus formed sends its current through a circuit in the torpedo containing a platinum fuze, which exploding sets off the charge. Other patterns of this type are arranged with a Leclanché battery placed in the anchor, or in the torpedo itself; an ordinary circuit closer completes the circuit and fires the fuze when the torpedo is struck by a vessel. By extending a part of the circuit to a distance from the torpedo through a short armored cable it is possible to render the torpedo safe to handle and plant, a break in the circuit in the branch cable being mechanically closed after the mine is planted and the boat is at a safe distance. Other patterns are provided with a break in the circuit, which is automatically closed after the mine is planted by the dissolving of a piece of sugar, or by some similar device. Mines of this class find only a limited application in our system; but at such places as Sandy Hook, where some of the channels are remote from the forts and can be sacrificed without injury to our own operations, they would be used. They would always be applicable to temporarily close gaps caused by the enemy, or to fortify positions in rear of the regular mined area if it appeared that the enemy was succeeding in forcing a passage.

Mines under control.—By the aid of electricity it is easy to bar a channel against any enemy by a system of automatic mines which can be made inoperative, and hence absolutely safe for our own vessels, at the will of the operator. This is accomplished by placing mechanism in the mine, which at the blow of a vessel shall, as desired, open or close an electrical circuit in the mine. This circuit contains a low tension fuze bedded in the explosive charge, and is extended to the shore by an armored cable, like those used in deep-sea telegraphy. At low-water mark the cable enters a horizontal gallery, leading to a vertical shaft, which opens in a secure casemate, where is stationed the operator with his apparatus. This apparatus consists of a powerful firing battery, which will ignite the fuze if allowed to send a current through it; a signal battery too feeble to endanger the fuze, but strong enough to operate an electro-magnet in the casemate when flowing through the fuze and mine; some form of relay capable of automatically regulating the flow of these batteries through the circuit; and, lastly, of various galvanometers and other apparatus for testing the condition of the mines and cables, and a telegraph connecting with an exterior observation station. In such a system everything depends upon the will of the operator. If he removes the firing battery wire the mines are inert, and the way is open to our own vessels; if he attaches this wire to the relay any mine struck by an enemy will explode with the certainty of fate. Should he desire to fire any particular mine, the operator can do so at once. In fogs or dark nights he can connect to his relay wires leading to certain guns charged and pointed to sweep the water over particular mines; and an enemy attempting to grapple or injure the system will not only draw upon himself a tremendous volley of canister or casé shot, but will also indicate his position to the garrison, who will continue the fire with the machine guns. The electric light can at will be flashed upon the channel in aid of the defense. It requires no argument to prove that 4 or 5 miles of channel thus obstructed will be no small obstacle to an advance, and if at the same time it be swept by a heavy fire of modern artillery, and be covered by movable fish

torpedoes operated and controlled from the shore, the city in rear will be safe from insult, and the fleet in front will be free to operate in the most effective manner—secure in the possession of a haven of refuge should the fate of battle prove adverse.

REQUIREMENTS.

To make such a system of mines effective, four things must receive careful attention before the outbreak of war: (1) A supply of mines and their accessories must be in store; (2) the galleries, shafts, and operating casemates must be constructed and ready for use; (3) a sufficient number of instructed men must be available to plant and operate the mines; and (4) the flanking guns, machine guns, electric lights, and other appliances for defending the mines must be properly mounted in secure land defenses ready for action. Our actual condition in respect to these requirements will now be considered.

(1) As to the supply of mines in store, the small appropriations granted by Congress have been expended in purchasing such parts of the system as are most difficult to procure and slowest to manufacture. At the depot at Willets Point are stored enough electrical apparatus to supply about forty casemates (five are required in New York Harbor alone), and enough torpedo cable to meet immediate demands. At New York, Boston, Philadelphia, and San Francisco a few mines without anchors or wire cables or other appliances are in store; but at no other points on our whole coast has any preparation been made. The cases cost from $150 to $300, according to size, which depends on the depth of water and strength of currents. Anchors cost from $20 upward, according to weight. It is not enough to equip our chief harbors; because a proper number of mines, operated even from the old forts, would protect harbors of minor importance, together with the vessels which had sought a refuge in them. The knowledge that the harbors of the North Sea and of the Baltic were defended by mines deterred the French fleet from approaching any of them during the late Franco-Prussian war; and the same protection proved sufficient for the Russian harbors on the Black Sea in the late Turko-Russian war. Some important object is needed to induce an attack upon any harbor known to be obstructed by mines, and places of little importance do not offer sufficient inducements to an enemy to risk the loss of his vessels. Hence, with our great ports properly defended, the rest of our coast can be cheaply protected by mines and the old forts. An annual appropriation not less than $100,000 for ten years, for submarine mines, may safely be recommended by the Board. No provision for explosives need be made, as they could be obtained at short notice in our markets.

(2) Galleries, shafts, and casemates for operating mines involve little expense Almost nothing has been done, although funds have been urgently requested for several years. An appropriation of $500,000 would go far to equip our whole Atlantic and Gulf coasts, and half that sum would meet the urgent needs of the Pacific coast.

(3) An instructed corps of submarine miners is absolutely essential. As is the practice with most European countries having extensive seaboards, Congress has devolved the service of submarine mines upon our engineer troops, in addition to their duties as sappers, land miners, pontoniers, &c. Until last autumn only about 130

men were under instructions at Willets Point; now the number is increased to about 375. At present this is probably sufficient; but when more material is in store the whole strength of the battalion authorized by law, 752 men, should be kept under training. The service is highly technical, and failure would be certain if officers and men without experience should suddenly be called upon to defend the coasts with mines.

(4) Flanking guns, machine guns, electric lights, &c., should not be neglected. These auxiliaries have in general received but little attention in this country. The old smooth-bore 10-inch and 8-inch guns in the existing casemated batteries (if themselves defended by modern ordnance properly mounted in modern defenses) would be of great service. No provision for machine guns or electric lights has been made except experimentally.

(B) MOVABLE TORPEDOES.

These torpedoes belong to two distinct classes—those under control and those not under control during their course. The former in general have a range of about two miles, and may be operated from shore stations. The latter are so liable to be accidentally deflected after starting that the best authorities do not concede an effective range of more than about 400 or 500 yards; in other words, they pertain to offensive warfare, and should be operated from vessels capable of selecting suitable positions for firing.

FUNCTIONS OF MOVABLE TORPEDOES UNDER CONTROL.

No torpedo of this class can claim an officially certified speed of more than about 12 miles per hour for a run of 1.5 miles. This is not enough to warrant the expectation of chasing an enemy's ship with success. Moreover they are too unwieldy for use at sea. Their true function appears to lie in repelling attacks upon submarine mines in position. When an enemy, by countermining, has opened a channel partly through the mined area, and is forced to remain in it to continue his operations, he becomes a target well suited for attack by a movable torpedo under control. It is therefore regarded as a useful auxiliary, and has received much attention both at Willets Point and Newport. Sims' torpedo has been developed at the former and Lay's at the latter station.

THE SIMS TORPEDO.

The Board of which Captain Belknap, U. S. Navy, was president, reported last autumn upon this torpedo for naval uses. (See report of Secretary of the Navy, Vol. I, 1884, pages 549 to 553.) This report contains a sufficiently detailed description of the torpedo.

Elaborate investigations have been conducted at Willets Point for the past five years to develop and improve this torpedo for use as an auxiliary to our submarine mines. Trials have been made with a 1-mile and a 2-mile pattern. They indicate that no serious injury need be feared from canister or machine-gun firing; that the torpedo will dive under a spar and continue its course uninjured; that it will carry a charge of 350 pounds of dynamite, at a probable speed of from 9 to 10 miles per hour, for a run of 1.5 miles; that it is fairly under control during this period; that it can be always ready to start at a few moments' notice, as the motive power is electricity

generated by a dynamo machine on shore. Should further trials prove this torpedo to have become a thoroughly trustworthy weapon for use in war, it will probably be recommended as an adjunct to our torpedo system. Its employment will be restricted to a few of the chief ports, where expensive preparations in the way of docks for starting bomb-proof casemates for the engine and dynamo supplying the current, observing stations, &c., will be required. It is still in the experimental stage, and no immediate appropriation, except for continuing the trials, is recommended.

THE LAY TORPEDO.

This torpedo and its various modifications have been thoroughly tested at Newport and elsewhere by naval officers. The report of Captain Belknap, already referred to, contains the latest details, pages 513 to 526, 537 and 548. The motive power is liquefied carbonic acid, which is difficult to have always ready for service in war.

It may prove valuable in the defense of harbors where the channel is contracted and the boat can be controlled from the shore. It is too large and too difficult to launch to be used from a movable platform. Indeed, it may be stated in general terms that any controllable torpedo is not suited to naval purposes at sea. The complications resulting from the effect of the motion of the torpedo and the motion of the ship upon the controlling cable would render the torpedo useless. It hardly seems necessary to say that a vessel could not be restricted to a position of rest while using the torpedo.

THE WEEKS ROCKET TORPEDO.

This torpedo also has been described and officially reported upon by the above-named Board. (See report of the Secretary of the Navy, Vol. I, 1884, pp. 526 and 540–543.)

THE HOWELL TORPEDO.

This torpedo seems to fulfill the principal requirements in a torpedo for naval purposes. It has also been described and reported upon by the same naval Board. Since that report three other experimental torpedoes have been constructed by the Bureau of Ordnance; and, upon a preliminary trial, one of them made a speed of 14 knots for a distance of 350 yards, at the same time towing a small buoy.

THE WHITEHEAD TORPEDO.

This torpedo is in general use by all nations except the United States. It is fish-like in form, and those recently constructed have attained a speed of 24 knots for a distance of 600 yards, carrying a charge of 70 pounds of explosive. The motive power is compressed air, which actuates an engine attached to a double propeller. It is usually fired from a tube by means of compressed air, and, more recently, a slow-burning powder has been used for ejecting it. This plan will probably become general, as it offers many advantages. No other torpedo has had so much thought bestowed upon its improvement, every possible means having been employed to render it as perfect as possible, and to reduce to a minimum the errors to which it is inherently subject.

(C) TORPEDO BOATS.

Within a few years a mode of warfare has developed which it is thought will completely revolutionize the art. Every nation in the world, except the United States, has taken the most active measures to provide itself with torpedo boats carrying either spar or Whitehead torpedoes—some nations in order to maintain their naval prestige; others, to defend their coast against the attacks of more powerful nations.

These boats are built to insure high speed and great handiness combined in a vessel of small dimensions. They have been divided in a general way into first-class and second-class torpedo boats. Those of the first class are about 115 feet in length, and capable of keeping the sea in company with large vessels. Those of the second class are carried by the larger vessels of war. Besides these two classes, which vary within considerable limits, there are torpedo "catchers" and torpedo "cruisers." The former are more powerful than the first-class boats, and are usually armed with several machine guns. Still larger than these torpedo catchers are the torpedo cruisers, 1500 tons or more, and capable of discharging torpedoes from six or eight points, and carrying an armament of several high-power guns. The nations of Europe now each possess from thirty to one hundred and fifty of these small boats for coast defense.

The coast defenses of Europe are being developed in this direction more than any other. Experiments on the most extensive and expensive scale are being made to try to determine the conditions and anticipate results of actual warfare.

On the subject of torpedo boats and Whitehead torpedoes, see lecture by Commander Gallwey on "The use of torpedoes in war," Journal of the Royal United Service Institution, Vol. XXIX. Also, Report of Secretary of the Navy, 1884, pp. 237–254.

SUBMARINE BOATS.

APPENDIX TO REPORT OF COMMITTEE NO. 2.

BY CAPTAIN EDWARD MAGUIRE, CORPS OF ENGINEERS, UNITED STATES ARMY.

(*Appendix to Report, Committee No. 2, Board on Fortifications or other Defenses.*)

UNITED STATES ENGINEER OFFICE,
Oswego, N. Y., September 28, 1885.

SIR: I imagine that the "Board on Fortifications or other Defenses" will discuss the subject of submarine boats, inasmuch as specifications for one have been sent to me to submit to the Board

As your committee in its report did not touch upon the subject, I have taken the liberty of sending you the accompanying paper. Much of it you are familiar with, but there are probably some members of the Board who have no knowledge of the subject. For that reason, and also for the reason that a history of the development of an art is always interesting and often useful in leading up to proper conclusions in regard to the possibility of any progress to be attained in the art, I have written the historical portion at length. The larger part has already been published, but in no one treatise is the whole of the information to be found, and therefore, to save the trouble of reference to a number of writings, I have rearranged it in the following pages.

I have tried to present as strongly as possible the arguments which may be adduced in favor of submarine boats, and no matter what the decision of the Board may be that decision will certainly derive force from the fact that it was made after the presentation of the subject in, it is thought, the fullest manner possible at the present time.

Very respectfully, your obedient servant,

EDW. MAGUIRE,
Captain of Engineers, U. S. A., Secretary of Board.

Lieut. Col. H. L. ABBOT,
Corps of Engineers, U. S. A., Chairman of Committee on Torpedoes, &c.

AUTHORITIES.

SARREPONT ..... Les Torpilles.
BARNES ..... Submarine Warfare.
BARBER ..... Submarine Boats.
SLEEMAN ..... Torpedoes and Torpedo Warfare.
VON EHRENKROOK ..... History of Submarine Mining and Torpedoes.
ABBOT ..... The Beginning of Modern Submarine Warfare under Captain-Lieutenant David Bushnell.

Various current publications.

NOTE.—In the following pages quotation marks are not always employed, for the simple reason that the exact language of the authority consulted is but seldom used.

E. M.

SUBMARINE BOATS.

Very many years have elapsed since man, for the first time, sounded the depths of the sea and attempted to open up a submarine theater of operations. It is useless to enter upon a history of his various attempts from the date when the ancients employed divers to cut the anchor lines and scuttle the vessels of their enemies, down to the invention of the diving-bell, which, although Aristotle refers to such a device, was, it is believed, first successfully employed in the sixteenth century.

The first attempt at submarine navigation, of which there appears to be an authentic account, was that of William Bourne towards the end of the sixteenth century. Half a century later, in 1624, Cornelius van Drebbel, a Hollander, realized such a project. He made some curious experiments under the waters of the Thames at London. His diving-boat, which was propelled by twelve pairs of oars, carried a dozen persons, among whom was King James the First. The merit of the invention consisted chiefly in a liquid, which enjoyed the property of purifying the air vitiated by respiration, and which bore the pretentious but significant title of "Quintessence of air." The inventor unhappily did not have time to perfect his apparatus; treated as a madman, as an agent of the devil, he died, and with him died his secret.

About the middle of the seventeenth century, Fournier (Hydrographia, 1643) and Mersenne (Phœnomænica Hydraulica, 1644) clearly expounded the theory of submarine navigation. In 1653, a Frenchman applied the theory so announced, and launched at Rotterdam a vessel similar to that of van Drebbel, but more easily controlled, notwithstanding its 72 feet of length. Later on, a marine engineer named Day constructed a diving-boat, but on his second trial-trip below the surface, he remained there and was never heard of afterwards.

Such is the historical summary of the first attempts at submarine navigation, attempts which were neither known nor understood by the public at the time. Bushnell certainly had no knowledge of them at the time he conceived his first submarine boat, and as Barnes says, "his submarine boat may justly be considered an entirely original conception." The following is an account of that boat, communicated by Bushnell himself in a letter of October, 1787, to Thomas Jefferson.

"The external shape of the submarine vessel bore some resemblance to two upper tortoise shells of equal size joined together, the flue of entrance into the vessel being represented by the openings made by the swells of the shells at the head of the animal. The inside was capable of containing the operator and air sufficient to support him thirty minutes without receiving fresh air. At the bottom, opposite to the entrance, was fixed a quantity of lead for ballast; at one edge, which was directly before the

operator, who sat upright, was an oar for rowing forward or backward; at the other edge was a rudder for steering. An aperture at the bottom, with its valve, was designed to admit water for the purpose of descending, and two brass forcing-pumps served to eject the water within when necessary for ascending. At the top there was likewise an oar for ascending or descending or continuing at any particular depth. A water-gauge or barometer determined the depth of descent, a compass directed the course, and a ventilator within supplied the vessel with fresh air when on the surface.

"The entrance into the vessel was elliptical and so small as barely to admit a person. This entrance was surrounded with a broad elliptical iron band, the lower edge of which was let into the wood of which the body of the vessel was made, in such a manner as to give its utmost support to the body of the vessel against the pressure of the water. Above the upper edge of this iron band there was a brass crown or cover, resembling a hat with its crown and brim, which shut water-tight upon the iron band; the crown was hung to the iron band with hinges so as to turn over sidewise, when opened. To make it perfectly secure when shut it might be screwed down upon the band by the operator or by a person without.

"There were in the brass crown three round doors, one directly in front and one on each side, large enough to put the hand through. When open, they admitted fresh air. Their shutters were ground perfectly tight into their places with emery, hung with hinges, and secured in their places when shut. There were likewise several small glass windows in the crown, for looking through and for admitting light in the day-time, with covers to secure them. There were two air pipes in the crown. A ventilator within drew fresh air through one of the air pipes and discharged it into the lower part of the vessel; the fresh air introduced by the ventilator expelled the impure light air through the other air pipe. Both air pipes were so constructed that they shut themselves whenever the water rose near their tops, so that no water could enter through them, and opened themselves immediately after they rose above the water.

"The vessel was chiefly ballasted with lead fixed to its bottom; when this was not sufficient a quantity was placed within, more or less, according to the weight of the operator. Its ballast made it so stiff, that there was no danger of oversetting. The vessel with all its appendages, and the operator, was of sufficient weight to settle it very low in the water. About 200 pounds of the lead at the bottom for ballast would be let down 40 or 50 feet below the vessel; this enabled the operator to rise instantly to the surface of the water in case of accident.

"When the operator would descend, he placed his foot upon the top of a brass valve, depressing it, by which he opened a large aperture in the bottom of the vessel, through which the water entered at his pleasure; when he had admitted a sufficient quantity, he descended very gradually. If he admitted too much, he ejected as much as was necessary to obtain an equilibrium by the two brass forcing-pumps, which were placed at each hand. Whenever the vessel leaked, or he would ascend to the surface, he also made use of these forcing-pumps. When the skillful operator had obtained an equilibrium he could row upwards or downwards or continue at any particular depth, with an oar placed near the top of the vessel, formed upon the principle of the screw, the axis of the oar entering the vessel. By turning the oar one way he raised the vessel; by turning it the other he depressed it.

"A glass tube, 18 inches long and 1 inch in diameter, standing upright, its upper end closed and its lower end, which was open, screwed into a brass pipe, through which the external water had a passage into the glass tube, served as a water-gauge or barometer. There was a piece of cork, with phosphorus on it, put into the water-gauge. When the vessel descended the water rose in the water-gauge, condensing the air within and bearing the cork with its phosphorus on its surface. By the light of the phosphorus the ascent of the water in the gauge was rendered visible, and the depth of the vessel under water ascertained by a graduated line.

"An oar formed upon the principle of the screw was fixed in the forepart of the vessel; its axis entered the vessel, and being turned one way rowed the vessel forward, but being turned the other way rowed it backward. It was made to be turned by the hand or foot.

"A rudder hung to the hinder part of the vessel commanded it with the greatest ease. The rudder was made very elastic, and might be used for rowing forward. Its tiller was within the vessel at the operator's right hand, fixed at a right angle on an iron rod which passed through the side of the vessel; the rod had a crank on its outside end which commanded the rudder by means of a rod extending from the end of the crank to a kind of tiller fixed upon the left hand of the rudder. Raising and depressing the first-mentioned tiller turned the rudder as the case required.

"A compass marked with phosphorus directed the course both above and under the water, and a line and lead sounded the depth when necessary.

"The internal shape of the vessel in every possible section of it verged towards an ellipsis as near as the design would allow, but every horizontal section, although elliptical, yet as near to a circle as could be admitted. The body of the vessel was made exceedingly strong, and to strengthen it as much as possible, a firm piece of wood was framed parallel to the conjugate diameter, to prevent the sides from yielding to the great pressure of the incumbent water in a deep immersion. This piece of wood was also a seat for the operator.

"Every opening was well secured; the pumps had two sets of valves. The aperture at the bottom for admitting water was covered with a plate perforated full of holes to receive the water and prevent anything from choking the passage or stopping the valve from shutting. The brass valve might likewise be forced into its place with a screw if necessary. The air pipes had a kind of hollow sphere fixed round the top of each to secure the air-pipe valves from injury; these hollow spheres were perforated full of holes for the passage of the air through the pipes. Within the air pipes were shutters to secure them should any accident happen to the pipes or the valves on their tops.

"Wherever the external apparatus passed through the body of the vessel the joints were round and formed by brass pipes, which were driven into the wood of the vessel; the holes through the pipes were very exactly made, and the iron rods which passed through them were turned in a lathe to fit them. The joints were also kept full of oil to prevent rust and leaking. Particular attention was given to bring every part necessary for performing the operations both within and without the vessel before the operator, and as conveniently as could be devised, so that everything might be found in the

dark except the water-gauge and the compass, which were visible by the light of the phosphorus, and nothing required the operator to turn to the right hand or to the left to perform anything necessary.

"In the fore part of the brim of the crown of the submarine vessel was a socket, and an iron tube passing through the socket. The tube stood upright, and could slide up and down in the socket six inches. At the top of the tube was a wood-screw, fixed by means of a rod which passed through the tube and screwed the wood-screw fast upon the top of the tube. By pushing the wood-screw up against the bottom of a ship and turning at the same time, it would enter the planks; driving would also answer the same purpose. When the wood-screw was firmly fixed it would be cast off by unscrewing the rod which fastened it upon the top of the tube

"Behind the submarine vessel was a place above the rudder for carrying a large powder magazine. This was made of two pieces of oak timber, large enough when hollowed out to contain 150 pounds of powder with the apparatus used in firing it, and was secured in its place by a screw turned by the operator. A strong piece of rope extended from the magazine to the wood-screw above mentioned, and was fastened to both. When the wood-screw was fixed and to be cast off from its tube, the magazine was to be cast off likewise by unscrewing it, leaving it hanging to the wood-screw. It was lighter than the water, that it might rise up against the object to which the wood-screw and itself were fastened.

"Within the magazine was an apparatus constructed to run any proposed length of time under twelve hours; when it had run out its time it unpinioned a strong lock, resembling a gun lock, which gave fire to the powder. This apparatus was so pinioned that it could not possibly move, till, by casting off the magazine from the vessel, it was set in motion.

"The skillful operator could swim so low on the surface of the water as to approach very near a ship in the night without fear of being discovered, and might if he chose approach the stem or stern above water with very little danger. He could sink very quickly, keep at any depth he pleased, and row a great distance in any direction he desired without coming to the surface. When he rose to the surface he could soon obtain a fresh supply of air, when, if necessary, he might descend again and pursue his course."

In the first experiments with this boat, Bushnell took care to prove its strength to sustain the pressure of the water, when sunk deep, before he allowed any person to descend much below the surface, and he never suffered any one to go under water without having a strong piece of rigging made fast to it until he found him well acquainted with the operations necessary for his safety. After that he made him descend and continue at particular depths without rising or sinking, row by the compass, approach a vessel, go under her, and fix the wood-screw, &c. He found agreeably to his expectations, that it required many trials to make a person of common ingenuity a skillful operator. The first one he employed, his brother, Ezra Bushnell, was very ingenious, and made himself master of the business, but was taken sick in the campaign of 1776, at New York, before he had an opportunity to make use of his skill, and never recovered his health sufficiently afterwards. After various attempts to find

an operator to his wish, he sent one who appeared more expert than the rest, Sergeant Ezra Lee, to the 64-gun ship Eagle, lying near Governor's Island. Lee went under the ship and attempted to fasten the wood-screw into her bottom, but struck, as he supposed, a bar of iron. Not being well skilled in the management of the vessel, in attempting to move to another place he lost the ship, and after seeking her in vain for some time he rowed some distance and rose to the surface, but found daylight had advanced so far that he dared not renew the attempt.

Afterwards there were two attempts made in the Hudson River above the city, but were failures. Soon afterwards, the enemy went up the river and pursued the vessel which had the submarine boat on board and sunk it with their shot. Bushnell afterwards recovered his boat, but found it impossible to prosecute the design further.

General Washington, in a letter to Jefferson dated September 26, 1785, stated in regard to Bushnell:

"That he had a machine so contrived as to carry him under water at any depth he chose, and for a considerable time and distance, with an appendage charged with powder which he could fasten to a ship and give fire to it in time sufficient for his returning, and by means thereof destroy it, are facts I believe which admit of little doubt. But, then, where it was to operate against an enemy, it was no easy matter to get a person hardy enough to encounter the variety of dangers to which he would be exposed—first, from the novelty; secondly, from the difficulty of conducting the machine and governing it under water on account of the current; and thirdly, from the consequent uncertainty of hitting the object devoted to destruction without rising frequently above water for fresh observations, which, when near the vessel, would expose the adventurer to discovery and to almost certain death. To these causes I always ascribed the failure of his plan, as he wanted nothing that I could furnish to insure the success of it."

The above-mentioned vessel, magazine, &c., were projected in 1771, but not completed until the year 1775.

Finally appeared Fulton, who, borrowing the ideas of Bushnell, took a great stride in the art of submarine navigation.

He went to Paris in 1797 to solicit the support of the Directory, but his projects having been referred to the Minister of War were by him deemed impracticable. The American engineer was not discouraged; he made a mahogany model of his proposed boat and presented it anew to the Directory, which then appointed a commission to examine it. The commission reported favorably, but the Minister of Marine positively refused to recommend its adoption. After three years of vain solicitation Fulton found the opportunity of offering his services to Napoleon, who entertained them, and commissioned Volney, Monge, and Laplace to make a thorough test of the submarine boat, and the sum of 10,000 francs was ordered to be paid to Fulton to defray the expenses of the experiments.

On the strength of that encouragement, Fulton, in 1800–1801, built a diving-boat which was propelled by two parallel screws. It was made to descend and ascend by means of screws which worked vertically. The experiments were made first at Rouen, then at Havre. Thence Fulton went to Brest. During that journey he greatly disturbed the cannoneers of the coast batteries, who saw him suddenly disappear under the water to reappear a few moments later on the surface.

Soon afterwards he built at Paris a second boat, more elegant than the first, and which bore proudly on its taffrail, in letters of gold, the name Nautilus. This new diving-boat had iron ribs and was sheathed with copper. It was of an elongated ovoidal form. On the deck was a groove in which lay a small mast which could be shipped by means of a hinge. In the interior, which was about 6 feet in diameter, were the handles of the oars which were arranged in the form of a screw. A reservoir, into which water was introduced, caused the Nautilus to descend at will; a force-pump expelled the water and allowed the boat to ascend. Finished in June, 1801, the Nautilus was tried on the Seine, above the Hôtel des Invalides. Fulton having shut himself up in his boat, with a sailor, carrying a lighted candle, descended under water, remained there for twenty minutes, and emerged after having gone a considerable distance. He again descended in order to regain the point of departure. He then reappeared at the surface and sailed several stretches, amid the applause of the assembled multitude.

The experiments were continued at Brest. The following is an extract from the report of the naval officers charged with observing his experiments:

"On July 3, 1801, the engineer, accompanied by three men, went aboard of his boat in the harbor of Brest; he descended to the depth of 25 feet, and remained under water for an hour, moving in all directions at will. On July 24th he replaced his candle, which consumed too much of the respirable air, by an opening in the top of the boat, fitted with thick glass, which allowed sufficient light to penetrate to enable him to count the minutes by his watch. On the 26th he adapted to the Nautilus a mast, a large sail, and a jib. Suddenly, in the middle of the harbor, he struck the sails and mast and prepared to descend. His preparations consumed in all only two minutes. The boat had a speed under water of one meter per second; it was under perfect control, and could be handled as well as on the surface. The compass at no depth whatever lost any of its magnetic properties. On the 7th of August following there was a final experiment. Fulton carried in his boat a cubic foot of compressed air and remained under water four hours and twenty minutes."

By direction of the commission a small vessel was provided and Fulton directed to destroy it. He placed under the vessel, by means of the Nautilus, a torpedo which blew it into fragments.

Notwithstanding this success the French Government did not think it ought any longer to encourage submarine navigation. Besides, Napoleon grew tired of waiting for the accomplishment of certain improvements which were judged necessary. Victim of his own impatience, he finally declared the invention impracticable. Eight years later, however, he had the Coëssin Brothers build a small diving-boat, which bore the name of Nautile, and which was tried at Havre. A committee of the Institute, composed of Biot, Monge, and Carnot, was ordered to make a report upon the boat. The three savans reported as follows: "There is no longer any doubt that submarine navigation may be established very expeditiously and at little cost" The report of the commission bears the date of April 11, 1810. The report was published and commented on by competent men, notably Castera, but found no echo.

In Niles' Register there is an account of a submarine boat and a description of a chase in which the vessel escaped her pursuers by diving "like a porpoise." From the description given this boat does not appear to have differed much from Bushnell's boat.

Fulton always had faith in the future of his work. Repulsed by France and also by England, he returned to America, where he undertook the construction of a new submarine boat which his death in 1815 prevented him from completing. That boat, called The Mute, was 80 feet long, 22 feet wide, and 14 feet deep. Its hull was a foot thick. The deck was covered with iron plates. It was intended that the boat should habitually run on the surface like ordinary boats, but on approaching the enemy it was to dive quickly under the water.

An Englishman named Johnson formed a project for releasing Napoleon from St. Helena. For that purpose he constructed a diving-boat 100 feet long, but it was confiscated by the English authorities, whose suspicions had been aroused. Some years later Johnson navigated the Thames in a submarine boat, on board of which several persons remained eight to ten hours without suffering any inconvenience.

Another Englishman, named Shuldam, experimented at Portsmouth, about 1824, with a boat in which he could easily descend to a depth of 30 feet.

Finally, in 1825, Mons. de Montgéry, a distinguished officer of the French navy, gave publicity to his plan of construction of his vessel, the Invisible.

The Invisible was a diving boat, 86 feet long, 23 feet broad, and 14 feet deep, or rather such were to have been her dimensions had she ever been built. The following is Mons. Montgéry's description:

The upper portion of the Invisible is almost exactly like the lower, but is sensibly flattened out in order to facilitate maneuvers when navigating on the surface of the water. It is provided with two hatchways, which allow the crew to pass in and out, and supplied with patent lights (*verres lenticulaires*) to light the between-decks. The bowsprit can be drawn in at will; the vertical masts work on hinges. When it is desired to descend, the rigging is stowed in a groove along the middle of the deck. The interior of the boat is divided into two parts by another deck; the lower part is itself subdivided into compartments, in which are stored the munitions and the volume of water whose weight causes the immersion. In order to dive, all that is necessary is to open some cocks. When it is desired to ascend, force-pumps are used to expel the water admitted to cause the descent. Movement in a horizontal direction is caused by means of a wheel at the stern and three blades operating on each side of the boat.

In 1850 a Frenchman named Alexandré made experiments with a submarine boat in New York Harbor. He claimed to be able to descend to a depth of 50 feet and then come at will to the surface. Nothing further was heard of this invention.

During the Schleswig-Holstein war a submarine boat was constructed at Kiel for the purpose of blowing up the Danish war ships anchored in the Sundewitt. This boat was built by a Bavarian artillery sergeant named Bauer. The Danish fleet being compelled, in January, 1851, to seek the high seas on account of the severe winter, the boat was never used in actual warfare, although all the necessary arrangements had been made for it. An experiment was made with the boat in February of the same year, and it proved a failure. The Austrian Marine Journal of 1853 states that this submarine boat was yacht-shaped and had in its stern a screw for horizontal movement. In the bow was a species of pipe provided with round windows, and a hatchway to serve as an entrance for the crew. Gutta-percha gloves were attached in such a manner as

to allow the pilot of the boat to fasten the torpedo to the enemy's vessel. The charge was to be fired by a voltaic battery. The hull of the boat was made of iron, but, like the pumping machinery, does not appear to have been strong enough. The boat, on its trial trip, after diving down some distance, had not sufficient power to rise to the surface again and went to the bottom. A leak having sprung at the same time, Bauer and his two companions came near losing their lives. The action of the entering water finally made the opening of the hatch possible, and the three men managed to escape to the surface. The boat weighed 7,000 pounds. An attempt was made to raise the boat in 1876 during the summer exercises of the School of Divers of the First Imperial Dockyard Division. The boat could not be found, and had probably sunk entirely into the mud.

In 1853 the subject of submarine navigation was revived by James Nasmyth. That engineer proposed a species of boat which he regarded as the carriage of an immense submarine mortar which was to fire a large cylindro-spherical shot. A percussion apparatus was to project the shot at the instant of collision with the lower works of a hostile ship. The great thickness of the hull of the "floating mortar," as well as its constant state of almost complete submergence, was to protect the crew, the machinery, and the screw.

In 1855 a Russian mechanic built a diving boat which was under perfect control, and in which he could remain under water for eight hours.

Another submarine boat of ovoidal form was exhibited in 1855 at the Paris Exposition.

The Government of the United States also constructed a diving boat at an early period of the rebellion. Its inventor was a Frenchman, to whom the Government paid the sum of $10,000 for his machine, and entered into an agreement with him by which he was to operate the vessel against the enemy, under the command of an officer selected by the Navy Department. For every successful enterprise in which he and his boat should be engaged he was to receive an additional sum of $5,000. This boat was built under his superintendence at the Washington navy-yard, and an officer applied for and received orders to take charge of her, with the express design of using her to blow up the rebel iron-clad Merrimac, at Norfolk.

Upon reporting for his novel command this officer found the boat apparently completed; but the inventor, having received the $10,000, had decamped, taking with him the knowledge necessary to the operation of the principal part of the invention, which was an apparatus for restoring the air in the boat after it became impure by breathing.

The boat was built of boiler iron, treble riveted, in form like a cigar, 35 feet long and 6 feet in diameter. It was to be made to descend by admitting water into compartments which extended her full length, and made to ascend by expelling the water by means of two force-pumps. The weight of sixteen men was required to sink her when the compartments were full. It was propelled above and below the surface by sixteen oars, eight on each side. Each oar was constructed on the principle of the webbed foot of a water fowl, being formed of two pieces, opening and closing like a book, hung at their junction to a rod which was connected with a crank designed to be worked

backward and forward by manual labor. It was found upon trial that a speed of only 2½ knots could be attained on the surface by this machinery worked by a full crew of sixteen men.

A row of thick glass "dead-lights" admitted light to the interior, where were two machines intended to purify and restore the air. One was a chemical apparatus to manufacture oxygen, and the other consisted of a vessel containing lime, with a bellows attachment by which the air was to be forced through it. Owing to the disappearance of the inventor, who alone pretended to understand its operation, this apparatus was never tested; in fact, it was considered that he had imposed upon the officials of the Navy Department, and that the invention was worthless. Nothing was ever accomplished with the boat beyond making a few experimental trips to the bottom of the river. She was subsequently fitted with a propeller and sent in tow of a steamer to Port Royal, but was lost in a gale off Cape Hatteras. It has been stated that it was part of the inventor's design to emerge from the boat in submarine armor when the boat was beneath a ship, and, having attached a torpedo to the ship's bottom, return to the boat, leaving the torpedo to be exploded by its own machinery.

About the same time another Frenchman, named Villeroi, built at Philadelphia a diving boat 35 feet long and 44 inches in diameter. This submarine boat was propelled by a screw 3 feet in diameter. The water necessary for submergence was pumped into gutta-purcha tubes. It was of a very elongated ovoidal form, the forward end being shaped like the head of a porpoise.

Confederate General Maury, in his report upon the defenses of Mobile, gives the following account of the submarine boat which sunk the Housatonic.

"It was built of boiler iron, about 35 feet long, and was manned by a crew of nine men, eight of whom worked the propeller by hand; the ninth steered the boat and regulated her movements below the surface of the water; she could be submerged at pleasure to any desired depth, or could be propelled on the surface. In smooth, still water, she could be exactly controlled, and her speed was about four knots. It was intended that she should approach any vessel lying at anchor, pass under her keel, and drag a floating torpedo, which would explode on striking the side or bottom of the ship attacked. She could remain submerged for half an hour without inconvenience to her crew. Soon after her arrival at Charleston, Lieutenant Paine, of the Confederate Navy, with eight others, volunteered to attack the Federal fleet with her. While preparing for their expedition the swell of a passing steamer caused the boat to sink suddenly, and all hands, except Lieutenant Paine, who at the moment was standing in the open hatchway, perished. She was soon raised and again made ready for service. Lieutenant Paine again volunteered to command her. While lying near Fort Sumter she capsized and again sunk in deep water, drowning all hands except her commander and two others. Being again raised and prepared for action, Mr. Aunley, one of her constructors, made an experimental cruise in her in Cooper River. While submerged at great depth, from some unknown cause she became unmanageable, and remained for many days on the bottom of the river with her crew of nine dead men. A fourth time was the boat raised, and Lieutenant Dixon, of Mobile, of the 21st Volunteers, with eight others, went out of Charleston Harbor in her and attacked and sunk the Federal steamer Housatonic. Her mission at last accomplished, she disappeared forever with her crew. Nothing is known of their fate; but it is believed they went down with their enemy."

In 1859 a submarine boat was exhibited in London by an American named Delaney, of which the following is a vague description: The boat was egg-shaped in transverse section, and diminished nearly to a point at each end. There was a rudder

at one end of a hollow shaft, and the axis of a screw-propeller passed through the shaft. There were two iron tanks in the interior, and one had air forced into it by a pump. A pipe with a cock communicated with the other tank, which contained water and had another pipe and cock opening outboard. The engineer of the boat, by forcing water into or out of the second tank by means of the air in the first one, was enabled to raise or lower the boat in the water. She was propelled by steam, and provision was made for purifying the air.

A man named Phillips launched his first boat in Lake Michigan in 1851. It was cigar-shaped, 40 feet long and 4 feet in greatest diameter, and in the course of a few years he so far perfected his arrangements for purifying the air, &c., that on one occasion, taking his wife and two children with him, he spent a whole day in exploring the bottom of the lake. His plans may be generally described as follows: The vessel is to be cigar-shaped, though this may be modified according to circumstances, being careful to preserve however, in all cases, a circular cross-section, which is necessary in order to give the required strength as well as to make her steer with equal facility in all directions. The longitudinal section may be that of a cylinder in the middle and of an ellipsoid at each end, or the ends may be ogival. Water tanks run fore and aft of the cylindrical portion of the boat on each side of and underneath amidship passage-way; they are of sufficient capacity to submerge the vessel when they are partly filled with water, or to raise her when they are empty and the remainder of the vessel full of water. Each tank has a cock connecting it with the external water, all the cocks except the center one being worked by a single rod; there is also a cock on the top of each tank for permitting the air to escape from it into the country of the boat, and a pipe with cock connecting it with the compressed-air cylinder arranged along the skin of the vessel just above the water-tanks. It is provided with a lookout or cupola, capable of sliding up or down, and underneath are the wheel and compass. It is also provided with an air-pipe, capable of sliding down in a socket so as to come wholly within the boat, but when slid up enables the occupant of the boat to receive fresh air when 4 feet under water. It has rudders for lateral steering, but no diving rudders or fins, since all vertical motion may be effected by the admission and discharge of water. The bow of the boat works with a hinge so as to be removable at pleasure, the object being to facilitate the use of tools outside the boat. Abaft this false bow is a bulkhead, through the center of which works a ball-and-socket joint, and through this ball a sleeve. The whole body of the boat is provided with deadlights, but when very deep in the water a peculiar lamp constructed by the inventor is used. The purification of the air is effected as follows: Along the top of the water-tanks runs a pipe connecting with the air-pump, and at intervals along this pipe hang pieces of hose terminating in rose-heads. The air-pump is also connected on the suction side with a pipe opening into the country of the boat, and by working the pump the foul air in the boat is drawn in and forced through the pipe on the top of the water-tanks and out at its only openings, the rose-heads. This causes the air to be disseminated through the water in fine particles, which rise in bubbles to the surface, and is thus washed free of its carbonic acid, which is absorbed by the water. The air thus passes again into the country through the vent-cocks in the tops of the tanks.

The inventor has found this method of treatment sufficient to keep the air respirable for ten hours, when three or four occupants were in the boat. As soon as the water in the tank becomes foul, it is forced out by compressed air and fresh water admitted.

The boat is kept at any given depth by an apparatus in the middle of the boat, which works automatically. Besides suspending the boat at any given depth, the inventor has also devised an apparatus for keeping it on an even keel, so that it will always be parallel to the surface, and the moving of weights from one end of the boat to the other will not disturb its equilibrium. The propeller is two-bladed and usually worked by hand. In his original boat the inventor gained a speed of 4½ knots per hour by this means with two men at the cranks. He has, however, devised a steam-boiler to generate steam under water for driving an engine continuously. The arrangement is very ingenious, and theoretically it would probably work, but in practice it would seem the apparatus would heat the entire boat so much as to render it unendurable.

The air-cylinders, which contain the large supply necessary for the different operations of this boat, are about 8 feet long and 13 inches in diameter, made of ¾-inch iron, riveted, and the seams brazed. In these the inventor claimed to be able to "put up" a pressure of 500 pounds per square inch by a small two-cylinder air-pump, worked by himself.

The construction of Phillips's boat, designed for war purposes, was very similar to the above, except that the diameter was about one-eighth the length instead of about one-tenth, and the upper part was heavily plated as a defense against grape and small-arms. The invention dates back to 1851, but minor improvements and inventions were made from time to time since then. The inventor is dead, but the plans of his invention were sent to the naval torpedo station in 1870 by one Blatchford, of New York. It has been stated that Phillips, who was a shoemaker by trade, descended in Lake Erie, near Buffalo, in a wooden boat, constructed on his principles, and as the boat never reappeared it is supposed that he accidentally went too deep and the boat was crushed by the pressure of the water.

Towards the close of 1863 an American, named Alstilt, is said to have constructed at Mobile a submarine boat, of which, like that of Villeroi, only a drawing and an unsatisfactory description have been obtained. It was made of sheet-iron, and was 65 feet long, with a deck near the center, which divided it into two parts. Above the deck was the machinery, compressed air, and gear for working two rudders, while below were a number of compartments for water, coal, &c. It was propelled by means of a screw which was put in motion sometimes by a steam-engine and sometimes by electric motors. When the vessel had nothing to fear from the enemy, the lower compartments were filled with air, and the boat traveled on the surface as an ordinary steamer. But at the instant of danger the compartments were filled with water, the boat descended, the fires were hauled, and electricity substituted for steam. Only one man remained in the glass conning tower to steer, the remainder of the crew descending to their compartment. In order to become invisible the boat had to descend only about 3½ feet; at this depth the sun's rays were sufficient to light the interior.

The same year, 1863, Admiral Bourgois, of the French navy, had charge of experiments made at Rochefort with a diving-boat, invented by a naval constructor named Charles Brun. It was of the form of a large fish, or short cigar flattened for a third of its circumference; it was 44.5 meters (about 146 feet) long, and 3.6 meters (about 12 feet) in height; its draught, when floating on the surface, was 2.8 meters (about 9 feet); it therefore rose above the surface only 0.8 meter (about 2½ feet); its stern was hollowed so as to contain a screw, a vertical rudder, and two horizontal rudders, the latter serving to facilitate the descent or ascent of the boat; it contained an 80 horse-power engine, driven by compressed air, and a large number of tubular reservoirs in which air was compressed to 12 atmospheres; immediately below these tubular ones were other reservoirs to receive the water, which served as ballast for the boat and cause the submergence. To drive out this water it was only necessary to connect the lower reservoirs with the compressed-air tubes. This boat, called Le Plongeur, was also provided with a mechanism by means of which a certain portion of its turtle-back could be detached and suddenly transformed into a life-boat for the crew, which numbered a dozen men. Launched in May, 1863, it was tried in the river Charente, and then on the open sea, under the direction of Admiral Bourgois and Lieutenant Doré. The experiments were said to have been completed in a satisfactory manner on February 25, 1864.

In the same year, 1864, an American, named Winans, experimented on the Thames with a boat about 256 feet long and of almost the same form as the Plongeur.

Towards the end of 1864 a submarine boat, called the Ictineo, was launched in the harbor of Barcelona, by a Spaniard, named Narciso Monturiol, but all experiments with it were secret and very little is known of it.

In 1865 a mechanic of Stockholm invented a submarine boat and the newspapers of the same year contained accounts of a diving-boat invented by a Frenchman named Deschamps. This boat was of the form of a fish, and, in addition to the usual apparatus for taking in and discharging water, was provided with a pump for expelling the vitiated air and another pneumatic apparatus for supplying fresh air.

After the war the first submarine boat which gained any notoriety in this country, was the "Intelligent Whale." She was 26 feet long by 9 feet deep; made of boiler iron, about ½ inch thick, and had one center and two bilge keels of heavy timber. Propulsion was effected by a four-bladed screw driven by four men at the cranks. Two small copper tanks contained air under a pressure of 600 pounds per square inch. Two large tanks contained water for sinking the boat, and communicated both with the air-tanks and with the water inside of the boat. It was provided with a rudder and two fins for controlling the direction of the boat when under way. It had an iron cupola with bull's eyes for a lookout. A compass to indicate the course, a water-gauge to show the depth, and an air-gauge for showing the pressure of the air in the boat were also provided. It had two square gates which could be opened when necessary. The entrance was a circular opening on top. An apparatus was provided for spraying water through the air when it became foul, and thumb-valves in the top allowed the foul air to escape. The water-tanks were filled, for sinking the boat, by opening a

valve, and were emptied by pumps, or by the simple admission of compressed air. The boat would hold thirteen persons, and was tried in the Passaic River with that number on board. Her speed was about 4 knots. She was to be operated as follows: To sink, let the water into the tanks until the boat passes slowly beneath the surface; the four men then work the cranks and propel the boat; the man at the lookout working the fins and steering. Having arrived at the proper position, if in soundings, let go anchors; let air from the tanks into the boat until the air-gauge shows a pressure greater than the pressure shown by the water-gauge at that depth; then open one of the gates. A man, in submarine armor, then passes out of the boat, carrying an electric torpedo, the wires of which pass through holes in the side of the boat. Having placed his torpedo beneath the vessel he returns, and the torpedo is fired by a battery in the boat Wishing to rise, the gate is closed, communication is opened between the air and water tanks, and the water is driven out, causing the boat to rise. The United States Government had intended purchasing this boat and an installment of the price was paid; but a difficulty as to the ownership of the boat having arisen, nothing was done, and she lay at the Brooklyn navy-yard for several years. A trial was at length ordered in 1872. The result was reported as a failure.

In 1869 Passed Assistant Engineer John W. Kelley, U. S. N., submitted plans for a submarine boat, as did also Dr. Barbour, of New York, but neither of the boats was ever built.

In the same year the Prussian Admiralty approved of a project for a submarine boat presented by one Otto Vogel.

In 1872 plans of a submarine boat were sent to the naval torpedo station by one Rowell, of Wisconsin. It was never built.

In 1875, Mr. Holland, of Paterson, N. J., submitted plans of a submarine boat to be operated by a single individual, and therefore to be as small as possible. Its length was to be 15½ feet, breadth 1½ feet, and depth, exclusive of the projection on top, 2 feet. It was to be nearly square in section, with parabolic lines, and calculated for a speed of 5.8 knots per hour on the surface, and 3 knots per hour when wholly immersed. It is not known to have been built.

Lieutenant Barber refers to an invention of one Toselli, in 1874, which was not a submarine boat, and yet not a diving-bell, but was intended to be used for torpedo purposes in times of war. It consisted of a cylinder of boiler iron, 40 inches in diameter, and 10 feet high, divided into four compartments. The bottom contained lead, and served to keep the vessel in a vertical position. The next lower division was for water, which was admitted by a cock, and discharged by means of a pump. The middle division was the working room, and the top compartment was filled with the necessary amount of compressed air. It had a rudder and screw, the latter being worked by hand, and driving the vessel at the rate of about 25 feet per minute. It was intended to be connected with a ship. It was provided with two gauges, one to indicate the exterior pressure and hence depth of submersion, the other to show the pressure in the condensed air-chamber. It was also provided with a *camera obscura* by which the horizon could be scanned. With this device, called the "submarine mole," the nventor descended to the bottom of the Bay of Naples several times.

In the latter part of December, 1874, one Fernandez, of San Francisco, launched a submarine boat, but as far as learned it was not used under water.

In 1882 a submarine boat was invented by a Russian named Dgevetsky, and tried at Kronstadt. It was a very small boat, about 20 feet long, and weighed, when fully equipped, not quite two tons. It had the form of a cigar; its screw-propeller was moved by the feet of four men placed in the central part of the vessel beneath a small glass dome, through which the officer in command could see the submerged portion of the enemy's vessel, and accordingly direct the attack. The speed attained was 4 miles an hour, which was considered ample to enable a submarine attack to be made upon vessels lying at anchor or approaching. It was easily steered. It was constructed to descend to a depth of 50 feet; the descent or ascent was effected by means of weights made to slide upon longitudinal horizontal bars or guide-rails. When the boat was fully stored, charged, and equipped its normal position was just beneath the surface of the water, the upper surface of the glass dome alone emerging. When it was desired to descend to a certain depth the weights were slid forward and the propeller started. The depths attained were shown by a specially-constructed manometer. As soon as the boat had reached the desired depth the weights were moved back and the boat resumed a horizontal position. In order to rise to the surface the operation was reversed. The boat was provided with a couple of torpedoes, attached to it by levers. As soon as the boat passed under a hostile ship the torpedoes could be detached, and were so constructed as to mount upwards, and by means of a gutta-percha appliance attach themselves to the hull of the vessel. The boat then retired to a safe distance, paying out the leading wires. A supply of air compressed to $\frac{1}{50}$ of its normal volume was kept in a strong reservoir for the crew, and was supplied by means of valves of peculiar construction. Sufficient air was stored to last twenty-four hours and the exhaled gasses were absorbed by chemical means.

Some years ago Prof. J. H. L. Tuck experimented on the Pacific coast with a submarine boat. He afterwards came to New York and had such a boat built at the Delamater Iron Works, where, it is understood, it is still to be seen. The following is taken from the description of the boat as given by the Submarine Monitor Company, of San Francisco, Cal., in 1883:

The submarine monitor is an iron, cigar-shaped boat about 30 feet long and 6 feet in diameter. At the stern, in addition to an ordinary propeller and rudder, there is a horizontal rudder. Beneath the middle of the boat is a second propeller which functions vertically. On the top of the boat is an iron hatch, two small round holes, and a hollow iron pipe about 20 feet long which lies on the deck. These and one or two small holes in the bottom are all that can be seen from the outside.

In the interior of the boat, in the bow, are placed the electric storage batteries, packed close. There is a small force-pump which can be worked either by hand or by electricity, and which can be used either for air or water. There is an ordinary electric engine, with the revolving cylinder of which is connected the propeller shaft. Near it is a small wheel with simple accelerating gear worked by hand. Still further back are the tillers of the two rudders and the helmsman's seat. Just above the seat is a glass V-tube, one arm of which is attached to the top of the boat. By the aid of

clutches, both propellers can be run by the same engine. There is also suspended from the top a water-tight box having a door opening into the interior. The displacement of the boat is such that in its normal position only a small portion of the top appears above the surface. There is on its deck an air and water tight entrance to the hanging box referred to above. The boat is caused to descend in three ways. The first is by admitting water into compartments provided for the purpose; the second is to connect the electric engine with the propeller beneath the bottom of the boat, which by its revolutions in one direction draws the boat beneath the surface; the third method can be employed only when the boat is moving. When forced ahead by the stern propeller the horizontal rudder is turned downwards, and the boat dives down head first; by reverse processes the boat is caused to rise.

In case of accident to the electric engine, the propeller can be worked efficiently by means of the hand-wheel and accelerating gear. The depth of the boat below the surface is indicated by the V-tube, mentioned above, which is a simple instrument to gauge the pressure of the water.

Compressed air is carried, stored in suitable receptacles, sufficient for the use of the crew for a long while; but that supply is kept in reserve. A supply of fresh air is ordinarily secured while the boat is below the surface by means of the iron pipe which lies on the deck. When the boat is 15 or 18 feet below the surface the pipe is raised to a perpendicular position by a simple gearing, and its bottom comes into position over a valved opening leading to the interior of the boat. As the monitor is only 15 to 18 feet below the surface and the pipe is 20 feet long, the end of the latter rises above the surface of the water. By opening the valve and attaching the double air-pump, fresh air can be drawn into the interior of the boat, while the vitiated air can be expelled by the same pump through a valved exit provided for that purpose. The interior of the boat is lighted by an incandescent electric light. There are no windows in the boat, and therefore, in order to direct its course, the Captain in submarine armor stands in the hanging box, and thus obtains an unobstructed all-around view. He communicates with the helmsman by means of a telephone, which is attached to the helmet.

The crew need not exceed three men, a helmsman and two others, to manage the air and water pumps and keep everything in order.

Nordenfelt has constructed a submarine boat, of which the following is a description:

It is cigar-shaped; length, 64 feet; center diameter, 9 feet; but including a small conning-tower on the top and the sponsons on either side, its actual dimensions are length 64 feet, beam 12 feet, and depth 11 feet. It is built of Swedish mild charcoal steel throughout, the plates in the center being five-eighths inch thick, but toward the ends, as the diameter lessens, the thickness of plates decreases gradually to a minimum thickness of three-eighths inch.

The framing consists of angle-irons, 3-inch by 3-inch by three-eighths inch, placed thwartships every 3 feet.

The conning-tower, 12 inches high, is fitted with a cover, which can be easily swung round upon a pivot, to give easy ingress or egress to the three men who form

the crew. This cover has a glass cupola, protected by a shield, and the Captain, standing in the tower, has his head in the cupola, and hence an all-around lookout.

The sponsons on either side form wells, for the protection of two propellers, which act vertically. The boat, which is always kept horizontal and always buoyant, is by means of these propellers submerged and held at any desired depth, or permitted to ascend to the surface. Herein, the inventor claims, lies the perhaps most important and distinguishing feature of this submarine boat, viz: Since the boat is always buoyant and submerged only by the mechanical power of the side propellers, if for any reason the mechanism of the boat's machinery should get out of order, the boat would not sink, but would of its own inherent buoyancy rise to the surface. In the stern is the driving propeller, 5 feet in diameter, with a pitch of 7 feet 6 inches, and four-bladed. The rudder for port or starboard steering is placed abaft of this propeller.

In the bow of the boat and on either side are balance rudders on one and the same axle. These rudders are always maintained in a horizontal position by a weight attached to an arm fixed at right angles to the rudder axle. This weight will always maintain its arm in a vertical direction, and since the rudders are at right angles to it, they will always be kept in a horizontal position. It is also so arranged, if preferred, to have the weight instead of acting directly on the rudders, to act upon the valves of a hydraulic engine, which again controls the rudder. These rudders, with their weight, form what is termed "the longitudinal stability apparatus," and constitute another distinguishing feature of this boat. Its object and mode of operation are as follows: The greatest difficulty in constructing a safe submarine boat is to secure its maintenance of its horizontal position in respect to its length, more especially when in motion. This first Nordenfelt boat is calculated to stand a pressure of 100 feet head of water, but it is not the intention deliberately to descend to such a depth. It has been explained that the rudders are kept by the weight in a horizontal position, and hence if the head of the boat should at any time point downwards the boat would be at an angle with the rudders, which would then tend to force the boat to resume its horizontal position. The machinery of the boat is driven by steam, and consists first of a main driving-engine, which is compound surface, condensing, and consists of two cylinders 12 inches and 25 inches diameter respectively, with a stroke of 10 inches; secondly, of two small engines of 4 inches diameter and 6 inches stroke used to drive the blower when on the surface, and to drive the vertical side propellers when under water. The steam which drives the engines is supplied, while the boat is on the surface, from an ordinary marine boiler. Any kind of fuel may be used, but since there is a forced draught, anthracite coal is preferred as giving least smoke and most steam. When the boat is submerged steam is supplied by means of the heat which has been reservoired in water tanks, while the boat was on the surface. In the present boat this hot water is carried in two tanks as well as in the boiler and amounts to about 8 tons.

The boat contains an apparatus for cooling the air inside the boat; an apparatus for showing the life-sustaining properties of the air inside the boat; an apparatus for showing the depth of submergence; an automatic apparatus for stopping the vertical propeller when the boat arrives at a certain depth, and which starts them again as soon

as the boat rises from that depth. These apparatus, together with compass, barometer, thermometer, &c., give to the Captain all information necessary for his purposes.

In case of leakage there are powerful pumps which can also be used to lighten the boat by expelling the 8 tons of hot water if necessary. No compressed air need be or has ever been carried, and there is no provision for chemically treating the air for the reason that the air space of the boat is sufficient. The smoke-stack is telescopic. The following experiments were made with this boat:

(1) Four men were closely shut up in the boat for six hours without experiencing any inconvenience.

(2) The longest period which the boat has remained under water, the cupola and all submerged, with crew in boat and without coming to the surface, was one hour.

(3) The greatest depth at which the boat has been operated is 16 feet.

(4) It has always been possible by varying the speed of the vertical propellers to maintain the boat within 1 foot of any desired depth.

(5) The greatest distance the boat has traveled when completely closed and driven only by the heat reservoired in its tanks, is 16 miles; the speed maintained on this occasion was 3 miles per hour. The temperature in this experiment before opening up was 86° F. The boat can be safely trusted to do 12 miles under water.

(6) The greatest speed the boat has recorded was a little over 8 knots on the surface.

(7) The greatest distance it has traveled as an ordinary surface steamer without recoaling is 150 miles. A short time ago the daily papers contained a meager description of a submarine boat built at Fort Lafayette, New York Harbor, under the direction of Lieutenant Zalinski, of the Fifth Artillery. The New York Times stated that the inventor is the Mr. Holland who has twice experimented with previous inventions of the same class and failed. The present boat was damaged in the launching, and nothing further has been heard of it.

Foreign journals inform us that the German Government has adopted a new submarine torpedo boat, designed by a Danish engineer named Keifler, undertaking not to construct or use the same except with his permission and under his own immediate supervision. According to the Norddeutsche Allgemeine Zeitung, this new submarine boat is much more simple in design than the one constructed by Mr. Thorsten Nordenfelt. The Keifler boat is driven by means of a steam-engine, and is able to remain twelve hours under water with ease. She will carry only four men, namely, the officer in charge, two engineers, and a seaman gunner. She is designed not only to launch torpedoes, but to attach them to the sides of ships at anchor, and can be used with advantage for destroying submarine mines and removing obstructions to navigation. It is stated that the German naval authorities are sanguine that they have secured in the Keifler boat the most practical design of submarine boat yet invented.

The *Engineering*, of recent issue, states, in effect, as follows:

"Submarine boats have been constructed by Mons. Goubet, of Paris. The first of these boats was completed in 1881, and led to an order from the Russian Government for the mechanism of three hundred boats, of which fifty were built at Paris, and delivered early in 1883. The hull of the boat can be opened at the upper part to admit the entrance of the officer and man who form her crew. These two having taken their places, the hatch is covered by a dome secured by hinges

and bolts, a joint being made by the edges taking into a recess lined with india-rubber. There are seven glazed openings in the hull, each covered by glass half an inch thick, and further protected by an external grating and internal shutter. Near the stern of the boat is placed the torpedo, containing 110 pounds of dynamite or other explosive. This is fastened by a catch-joint which can be operated from the interior of the boat. The torpedo is also attached to a conducting wire wound on a drum and connected with a commulator within the boat.

"In the interior of the boat are: a reservoir of compressed air, which serves as a seat for the men; the propelling mechanism, consisting of accumulators, dynamo, oars; the pump for removing water from the reservoirs when the boat has to rise; the air pump for expelling the vitiated air; the double-acting pump which preserves the stability of the vessel by the aid of two reservoirs and of a pendulum.

"The water reservoirs serve to effect the immersion of the boat, and are each divided into several compartments to prevent the water in them from surging backwards and forwards.

"The sailor opens a cock to permit the compressed air to flow into the boat. The air passes through the water reservoirs, in order to become saturated with humidity, and enters the dome. A gauge indicates the pressure in the reservoirs. The pump is put in action to expel the vitiated air. The man then starts the boat at the line of flotation and the officer directs its course. When it has arrived under the hostile ship, which may be seen through the upper window of the dome, the boat is maneuvered so as to obtain the best position, and then the torpedo is cast off to ascend by its flotative power, and attach itself to the vessel by its impact and a ring of spikes which it carries at its upper part. This done, the boat withdraws, paying out the conducting wire until a safe distance has been gained, say 100 to 150 yards. The circuit is then completed, and the explosion effected by electricity.

"An explosive signal forms a means of communication with the surface in case any accident should occur to the craft and prevent it rising, indicating by the loudness of the noise and the color of the flame the depth to which the boat has descended. It may also carry up with it a telephone wire, to form a means of communication if desired.

"Another safety appliance is found in a large weight fixed to the bottom of the boat and secured by a steel screw, which engages with a nut let into the body of the weight. Should an accident occur to the skin of the craft, or some necessity for a very rapid ascent to the surface present itself, the bolt is turned by a wrench until it withdraws itself from the nut, when the weight drops off, and the buoyancy of the boat carries her quickly to the surface in spite of the water in the reservoirs.

"Air compressed to fifty atmospheres is carried in sufficient quantity to supply the two men for ten hours. The carbonic acid given off by them during that time is absorbed by 1,500 grammes of caustic potash distributed in various parts of the boat. A slight amount of free chlorine serves to destroy any other exhalations.

"The power required to drive the boat, fully immersed, at a speed of five knots, is 42 kilogrammeters, and this could be developed by a Siemens motor working with a current obtained from accumulators.

"In case the motor should break down oars are provided.

"Two men are able to row the boat at the rate of three knots per hour when fully immersed. In the Russian boats the power was obtained by treadles worked by four men. * * * ."

Such is the history of the various attempts to attain submarine navigation. A great number of those attempts have been complete failures, while others have failed in certain respects. But, after all, certain results have been attained, viz:

(1) Submarine boats have been built in which several persons have descended (with safety) for a great distance below the surface of the water.

(2) Submarine boats have been propelled both on and under the surface in all directions.

(3) The problem of supplying the necessary amount of respirable air for a crew of several persons for a number of hours has been solved.

(4) Steam, compressed air, and electricity have been used as the motive power.

(5) The incandescent electric light has been used for illuminating the interior of submarine boats.

(6) Seeing apparatus have been made by which the pilot, while under water, may scan the horizon in all directions.

(7) A vessel has been, in time of war, destroyed by a submarine boat. The latter, it is true, was also sunk, but it was for reasons that are no longer in force.

Is there any future for submarine navigation?

Biot, Monge, and Carnot believed in the practicability of the ideas to which Fulton's Nautilus had given a palpable form. Fulton himself believed implicitly in a successful solution of the problem. Major Daudenart, an eminent officer of the French army, in his work entitled "La Guerre Sous-marine et les Torpédos," expresses the opinion that submarine navigation may soon assure to the torpedo a marked superiority in the attack on ships both on the high seas and in harbors. He thinks that the motive power will be compressed air, or steam and compressed air combined, the steam being produced by the heat generated by the combustion of petroleum in preference to coal. With this combination, he believes that the art of submarine navigation is called to a great success.

Barnes says:

"There seems no insurmountable objection in the way of the construction of a submarine boat; the principal difficulty has been one that ought to be remedied by the application of our increased knowledge of mechanics and chemistry since the period when it was first conceived—that is to regulate or purify the supply of air, so as to enable the operators of the boat to remain a considerable time beneath the surface. The general use of torpedoes, offensive and defensive, seems to lead to the introduction and use of such a boat, and it cannot be long before the inventive genius of man will supply the demand made upon it."

Sleeman says:

"Submarine boats, if they could be constructed to fulfill the conditions, hereinafter enumerated, which are essential to a perfect boat of that nature, would, for many reasons, be a very important point solved in connection with torpedo operations, and therefore it is most extraordinary that a practicable submarine boat has not yet been designed and built."

Hobart Pasha, in referring to a submarine boat, says:

"Here is one system which might be utilized if perfected. * * *"

Barber says:

"The science of submarine navigation is likely to be one of great importance in connection with the torpedo operations of future wars both for attacking vessels, and for entering harbors and destroying submarine mines and their connections, provided the present partial disadvantages connected with the use of diving-boats can be successfully overcome. These disadvantages seem to lie in the present imperfect solution of the problems of light and speed. The problem of speed would not appear to be so important as that of light. * * * The problem of lighting a submarine boat and of being able to illuminate at will at least a portion of the surrounding water must receive careful attention before we can hope to obtain very important results from underwater navigation. * * * Some form of the electric light, since it is very intense and perfectly independent of the atmosphere, will probably come nearer to supplying the wants of the submarine navigator in this direction than any other."

Sarrepont says that it is permissible to hold to the opinions of Mersenne, Biot, Monge, Carnot, and Daudenart, but with the understanding that the navigation in question shall not be absolutely and *exclusively* submarine; that it shall, on the contrary, constitute only an exceptional fact, a simple accident of the habitual navigation; that the boat shall not be a *submerged body*, but simply *submersible;* that it shall always possess flotation, however small it may be, on which depends the stability of equilibrium, which is absolutely wanting in purely submerged boats. A navigation purely and constantly submarine is impracticable. It has no other outlook than that of permanent danger, while one has a right to look for good war services from boats submersible at the will of the crews. These boats disappear below the surface for only a few short moments; they have, ordinarily, a small portion projecting above water, which prevents them from losing any of the sailing qualities suitable to boats *floating on the surface.* They have stability, are almost invisible, and remain in communication with the air. When their decks are at the surface of the water they burn petroleum, and their small armored stacks emit only an imperceptible smoke. When they are entirely submerged, compressed air becomes the motive force and supplies the crew with the necessary respirable air. With the above restrictions he considers that submersible boats have a great future before them.

It is indeed difficult to see why submarine torpedo-boats should not be brought to a degree of perfection commensurate with the ends to be attained by their use. In this age of great inventions and great scientific and mechanical knowledge, submarine navigation is not to be dismissed as an impossibility. Not many years ago it would have seemed almost incredible that a fish-torpedo could be constructed so as to be not only propelled but steered under water. Yet all Governments experiment with them and their development is not yet complete.

It is to be remembered that up to a comparatively recent date submarine mines were derided and scoffed at by both Army and Navy officers. Of one very able and eminent officer, Barnes says that he discountenanced any further proceedings looking to the further development of Colonel Colt's plans for submarine defense. Barnes also states that "Of a large number of officers of rank in the Navy as well as in the Army, who were invited by Secretary of War Conrad to give their views upon the sea-coast defenses of the United States, General Delafield is the only one who in any way mentions submarine defenses as available * * *." To-day that very system of submarine defense has been brought to a high degree of efficiency by an officer of the Corps of Engineers.

As late as 1829, four years after the opening of a railroad for commercial purposes, two distinguished engineers, Mr. Walker and Mr. Rastwick, solemnly urged the use of *stationary* engines instead of locomotives on the Liverpool and Manchester Railroad, then nearly completed. It is thus to be seen that even the best minds are sometimes inclined to pay too little attention to the possibilities of development.

Now, why have all of the great improvements in inventions been developed and made? Because there has been a practical commercial demand for them. For the development of any piece of mechanism a practical application of it is necessary, and that practical application of it must, like every other inducement in this world, have

a substantial value. The man who investigates purely for the love of science rarely accomplishes much; it is the man who looks for a solid return for his labor and study, either in dollars or professional advancement, who, as a rule, produces practical and useful results.

It will be remembered that it is only within a very few years back that any attention has been paid to surface torpedo-boats, for the simple reason that there was no demand for them. Now, every nation of any consequence in the world, except the United States, is earnestly engaged in developing them, and the time is ripe for the development of submarine torpedo-boats. Let there be a substantial reward offered for a practicable submarine boat, and it is believed that it will be forthcoming. The brains of practical men will be brought to bear on the subject, and instead of the visionary schemes of mere thinkers, we shall have the results produced by experienced practical workers.

It may be asked, "Of what use will submarine boats be for harbor defense?"

The reply is that they will be useful for all purposes for which a surface torpedo-boat can be used, and the utility of the latter must, in view of the opinion of the majority of mankind, stand unquestioned.

A submarine torpedo-boat, as compared with a surface-boat, will have the following advantages:

(1) It will not require to have so much speed. The surface-boat demands high speed to enable it to run quickly within striking range of its torpedo, and then run quickly out of the danger of injury by machine-guns, &c. The submarine boat being invisible, is not in danger.

(2) Being submerged in the presence of the enemy the engines will not be heard.

(3) There will be no smoke or glare from the fires to enable the enemy to detect it.

(4) Boat and crew being under water will be protected from the fire of machine-guns and rifles.

(5) Being under water and hidden from view it will be enabled to approach the enemy near enough to make even the uncontrollable fish-torpedo effective.

(6) It can be used as a reconnoitering or dispatch boat with safety.

(7) It can be used to examine the mine lines, to discover faults, or to replace mines exploded in action.

If submarine boats could accomplish nothing more than to force the commander of a vessel to resort to the tactics of Commodore Rogers, who, to defend the Argus from Fulton's attacks, put netting to the bottom of the water, then a great deal would be accomplished, for the vessel would be made inefficient.

But there is another great point to be considered, and that is the *moral* effect produced by such a boat. The moral effect of torpedoes, says Sleeman, "is undoubtedly the very essence of the vast power of those terrible engines of war. Each successive war that has occurred in which the torpedo has taken a part since Captain Bushnell's futile attempts in 1775 to destroy our fleet by drifting numerous kegs charged with gunpowder down the Delaware, teem with proofs of the great worth of torpedoes in that respect alone."

Sir Frederick Abel, in a lecture delivered before the Institute of Civil Engineers in London, says:

"* * * But of the moral effect of submarine mines we have already had abundant proof. In the war which was carried on for six years by the Empire of Brazil and the Republic of Paraguay the latter managed by means of submarine mines to keep at bay for the whole period the Brazilian fleet of fifteen iron-clads and sixty other men-of-war. * * * In the Russo-Turkish war submarine mines and torpedoes were a source of continual apprehension, and it is well known that the French naval superiority was paralyzed during the Franco-German war by the existence, or reported existence, of mines in the Elbe."

How much greater, then, will be the moral effect if the ship's crew know that the torpedo is not stationary and confined to one locality, but is moving stealthily beneath the water, giving no sign of its presence or of its time of attack? It is doubtful if, under such circumstances, a ship and its crew can do effective work. Let a good sailor or soldier *see* a danger, bring it before his eyes, and he will face it without flinching, but hidden danger, if only the possibility of its existence be suspected, will put any man's nerves to the rack, and nervousness is not compatible with good work. So, then, if submarine boats do no more than to keep the enemy in a state of nervous anxiety a great end will be attained.

One great objection urged against the use of submarine boats is that employed by Washington in regard to Bushnell's boat, namely, the novelty and hazardous character of the service. As for the novelty, of course men must be trained and accustomed to the service in time of peace, just as artillerists and engineers are drilled in the use of their weapons. That is the case with the surface torpedo-boat also. As for the hazardous character of the service, there is no truer saying than that the "hand of little employment hath the daintier sense." Men will soon become accustomed to operating a boat under water. It did not take our Navy long to overcome its disinclination to serve in monitors. Bushnell found men to operate his boat. Fulton, and indeed all of the successive inventors, found little trouble in obtaining assistants in their submarine operations. Even the fated boat which sunk the Housatonic was never without its crew. But let the practicability of the system be demonstrated by successes and its defects remedied by experience during time of peace, and there will not be wanting in time of war, crews whose nerves will be in a sufficiently good condition to enable them to perform their work well.

It is to be understood that by the term "submarine boat" is not meant one which shall at all times run under water, but one which can be submerged at will and run under water for some time with safety to the crew.

Since writing the above the following appeared in the London Times:

"The interest excited by the recent trials of the Nordenfeldt submarine boat is sufficiently shown by the presence at Landskrona of thirty-nine officers, representing every European power, together with Brazil and Japan. Such a boat, if successful, will exercise a powerful influence both on naval warfare and on coast defense. Its possible uses are manifold; its moral effects unquestionable. Against its operations no system of defense at present suggested seems adequate. The introduction of fast torpedo-boats has supplied a new factor in warfare, and, *pace* Hobart Pasha, their influence will some day make itself powerfully felt. But the torpedo-boat has been met actively by the machine-gun, capable of delivering an extremely rapid fire of small shell at ranges far beyond the useful limit of the Whitehead, and passively by the steel-wire netting with which it is proposed

to surround ships. Again, the torpedo-boat can be met and fought on the sea by similar boats, faster, better handled, or better armed. On the other hand, a boat which can maintain a fair speed under water for several hours, which need only rise to the surface for brief periods and can sink at will if discovered, which can li· *perdu* and direct a steered torpedo or run up to close quarters and fire the Whitehead at 10 feet below the surface, is undoubtedly an exceptionally dangerous antagonist. If the problem of producing such a boat can be solved, the largest ship would be secure only when in rapid motion, no port could be satisfactorily defended, and no system of submarine mines could be regarded as safe. Mr. Nordenfeldt has addressed himself to the solution with a measure of success which will be discussed later.

"It is no new problem. Submarine boats were employed in the American war, where some successes were claimed for them, and, considering the enormous advantages to be obtained, it is not surprising that at least one European power has devoted both time and money to experiment. But there has been a natural tendency to preserve secrecy on the subject, since to create the vague suspicion of the possession of a submarine boat would be a more desirable object than to proclaim the existence of one with known imperfections and limitations; besides, the past record of the performances of these boats has not been free from disaster. Several have sunk with their crews to rise no more; others have remained fixed and helpless at the bottom for long periods, to be saved only by exceptional coolness and exertion on the part of the crews. It would be clearly unwise to create an antecedent impression of the exceptional danger involved in their service at a time when such danger might be due chiefly to structural imperfection and want of knowledge; for the problem is no easy one when its conditions come to be realized. Power to sink and rise rapidly at will, fair speed under water, horizontal and vertical steering power under full control, endurance of motive force and air-supply for the crew are only some of the many requirements on the fulfillment of which success is dependent."

E. M.

REPORT OF THE COMMITTEE TO COLLECT INFORMATION AND REPORT UPON SHIPS OF WAR, THEIR ARMOR, ARMAMENT, AND DRAUGHT OF WATER; ALSO THE NAVIGABLE DRAUGHT OF ENTRANCES OF THE PORTS OF THE COUNTRY.

COMMITTEE No. 3.

Commander W. T. Sampson, U. S. N., Chairman.

Commander Caspar F. Goodrich, U. S. Navy.

NEW YORK, *July* 13, 1885.

The Committee appointed to collect information relative to ships of war, and to report upon their armor, armament, and draught of water, also upon the navigable draught of entrances of the ports of this country, has the honor to state that, in its present condition, the Navy of the United States possesses practically no vessels which could render efficient aid in the defense of our coasts. When completed, the monitors *Miantonomoh* and *Puritan*, etc., now in process of rebuilding, will be armed with high powered 10-inch and 10½-inch B. L. Rs., and will be able to give a fairly good account of themselves as against many foreign iron-clads, but their speed and other characteristics will doubtless restrict them to inside lines of operation, and they cannot be expected to prove of value against large vessels through their offensive powers.

A tabular statement, marked A, of the principal vessels in foreign navies is transmitted herewith. It was prepared in the Office of Naval Intelligence and may be regarded as containing the latest information obtainable. To illustrate graphically the scope of ships which carry guns of modern type, the Committee has marked upon the charts of certain of our harbors outside anchorages which might prudently be occupied by a heavy-draught vessel. From these anchorages as centers circles have been struck with radii varying by a mile. When it is remembered that the Navy 6-inch B. L. R. ranges over four miles at an elevation of but 10°, that recent gun carriages abroad are designated to permit an elevation of 20°, that vastly larger calibers than the one quoted are afloat in every navy in the world, and that, given the same initial velocity and elevation, the range may be expected to vary approximately as the caliber, it will be seen that the powers of the offense have been developed far beyond the anticipations of the day when our present coast defenses were planned. Although the actual extreme range of guns is still a matter of speculation and not demonstrated, it is well, from the standpoint of the defense, to exaggerate this element rather than to underrate it. Bearing this qualification in mind, the following table will be found interesting if not indeed valuable.

GUNS AFLOAT RANGING POSSIBLY 10 MILES OR UPWARDS.

Nation.	Ship.	Maximum armor.	Draught.	Guns.	Caliber.
		"	' "	*Number.*	*Inches.*
England	Conqueror	12	24 0	2	12
	Colossus	18	26 3	4	12
	Edinburgh	18	26 3	4	12
France	Amiral Duperré	21.6	26 9	4	12.4
	Dévastation and Foudroyant.	15	24 11	2 4	10.6 13.4
	Terrible	19	24 7	2	16.5
	Tonnant	17¾	16 9	2	13.4
	Vengeur	12¾	16 9	2	13.4
Italy	Italia	18.9	30 3	4	17
Germany	Salamander Natter Hummel	8	19 2	1	12
China	Ting Yuen Chen Yuen	14	20	4	12

GUNS RANGING POSSIBLY 10 MILES OR UPWARDS SHORTLY TO BE AFLOAT.

Nation.	Ship.	Maximum armor.	Draught.	Guns.	Caliber.
		"	' "	*Number.*	*Inches.*
England	Collingwood	18	26 3	4	12
	Rodney	18	25 3	4	13.5
	Benbow	18	27	2	17
	Camperdown	18	27 3	4	13.5
	Howe	18	27 3	4	13.5
	Anson	18	27 3	4	13.5
	Hero	12	24	2	12
	Renown	18	27 3	2	16.25
	Sanspareil	18	27 3	2	16.25
France	Am. Baudin	21⅝	26	3	16.5
	Formidable	21⅝	26	3	16.5
	Furieux	19⅝	21 7	2	13.4
	Indomptable Caïman Requin	19⅝	24 7	2	16.5
	Marceau Hoche Magenta	17¾	27.3	2 2	13.4 10.6
	Neptune	17¾	27 3	3	13.5
	Brennus	17½	26 8	4	13.4
	Charles Martel	17½	26 8	4	13.4
Italy	Lepanto	18.9	29 6	4	17
	Ruggiero di Lauria	17.7	25 11	4	17
	Andrea Doria	17.7	29 6	4	17
	F. Morosini	17.7	25 11	4	17
Russia	Catherine II	24	27	4	12
	Tcheame	24	25	4	12
	Sinope	24	25	4	12
Denmark	Tordenskiold	8	15	1	13.8

GUNS AFLOAT RANGING POSSIBLY 9 TO 10 MILES.

Nation.	Ship.	Maximum armor.	Draught.	Guns.	Caliber.
		"	' "	*Number.*	*Inches.*
England	Inflexible	24	25 4	4	16
France	Friedland	7½	29 4	2	10.6
	Redoutable	14	24 10	4	10.6
	Duguesclin Bayard Turenne Vauban	9½	24 10	4	9.5
	Fulminant Tonnerre	13	21 4	2	10.6
Italy	Duilio	21.7	28	4	17
	Dandolo	21.7	28 9	4	17
Germany	Sachsen Baiern Würtemberg Baden	17, 25	19 8	4	10.2
	Wespe Viper Biene Mücke Scorpion Basilisk Cameleon Crocodil	8	10 2	1	12
Brazil	Riachuelo	11	20	4	9

Besides a large number on unarmored vessels and on armored vessels not yet completed.

Inclosure B is a list of the various ports of the United States, with the minimum depths of water in their approaches.

Inclosure C contains a list of vessels classified according to draught of water and the ports which they can enter at half tide.

Inclosure D, also from the files of the Office of Naval Intelligence, contains a brief summary of population, commercial statistics, trade facilities of various ports, with other pertinent matter.

Inclosure E is a study of exposed points on our frontier lines of communication, and possible base of hostile operation, prepared in the Office of Naval Intelligence.

The Committee ventures, in conclusion, to call attention to the facts: that on the great lakes we are forbidden by treaty to maintain more than one armed vessel; that we possess no navigable communication between them and tide-water; that England has a large fleet of light-draught gunboats capable of passing through the Canadian canals and appearing without delay off the prosperous and wealthy cities of Buffalo, Cleveland, Sandusky, Detroit, &c; that our western coast is practically devoid of floating defense, and that the most powerful vessels on the Pacific coast of America are in the hands of a nation whose sympathies are alienated from us.

Respectfully submitted.

W. T. SAMPSON,
Chairman.

INCLOSURE A.

CHARACTERISTICS OF PRINCIPAL FOREIGN SHIPS OF WAR.

INCLOSURE

Characteristics of principal

(Prepared in the Office of Naval

[NOTE.—The dates given refer to year of launch and are all subsequent to 1870

ENGLAND.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions.				Battery.			
				Length.	Breadth.	Draught aft.	Displacement.	Number.	Caliber.	Type.	Power (inches of wrought iron at muzzle).
Barbette armored ships.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*		
Téméraire	Iron; sheathed; 1876; battle and cruising ship; belt and two barbette towers; brig rig; protective deck, 1½″ thick; condition good.	531	14.6	285 0	62 2	27 2	8,540	4	11	25-ton M. L	14
								4	10	18-ton M. L	13
Impérieuse	Steel; sheathed; 1883; barbette battle and cruising ship; partial belt; four barbette towers; unprotected broadside; protective deck, 2″ to 4″ thick, steel; brig rig; condition good.	400	16	315 0	62 0	25 6	7,390	4	9.2	do	19
								6	6	do	11.9
Warspite	Steel; sheathed; 1884; condition good	400	16	315 0	62 0	25 6	7,390	4	9.2	do	19
								6	6	do	11.9
Collingwood	Steel, 1882; barbette battle-ship; partial belt; two barbettes; unprotected broadside; protected from raking fire by bulkheads from towers to side; one mast; military top; protective deck, 2½″ thick; condition good.	423	16.84	325 0	68 0	26 3	9,150	4	12	43-ton B. L	26.8
								6	6	B. L	11.9
Rodney	Steel, 1884; type of Collingwood; protective deck 2½″ to 3″ thick; condition good.	445	*16	325 0	68 0	27 3	9,600	4	13.5	do	30.6
								6	6	do	11.9
Howe	Steel, 1885; sister ship to Rodney; completing	445	*16	325 0	68 0	27 3	9,600	4	13.5	do	30.6
								6	6	do	11.9
Benbow	Steel, 1885; type of Collingwood; deck 2½″ to 3″ thick; completing.	455	*16	330 0	68 6	27 3	10,000	2	16.25	110-ton B. L	32.5
								10	6	B. L	11.9
Camperdown	Steel; type of Collingwood; deck, 2½″ to 3″ thick; building.	445	*16	330 0	68 6	27 3	10,000	4	13.5	do	30.6
								6	6	do	11.9
Anson	do	454	*16	330 0	68 6	27 3	10,000	4	13.5	do	30.6
								6	6	do	11.9
Turret armored ships.											
Devastation	Iron, 1871; battle-ship; high freeboard; double turrets; breastwork monitor; one mast; protective deck, 3″ to 2″ thick; condition good.	358	13.84	285 0	62 3	27 6	9,330	4	12	35-ton M. L	15.5
Thunderer	Iron, 1872; type of Devastation (sister ship); condition good.	356	13.4	285 0	62 3	27 0	9,330	2	12.5	38-ton M. L	18.7
								2	12	35-ton M. L	15.5
Dreadnaught	Iron, 1875; type of Devastation; deck, 3″, 2½″, 2″ thick; condition good.	369	14.24	320 0	63 10	26 9	10,820	4	12.5	38-ton M. L	18.7
Neptune	Iron; sheathed; 1874; battle and cruising ship; two turrets; casemate; bark rig; built for Brazil; protective deck, 3″ to 2″ thick; condition good.	541	14.2	300 0	63 0	26 1	9,310	4	12.5	do	18.7
								2	8	11-ton B. L	14.4
Inflexible	Iron, 1876; battle-ship; partial belt; citadel and two turrets; unprotected ends; cork belt; two masts; protective deck, 3″ thick; condition good.	440	14.75	320 0	75 0	26 4	11,880	4	16	80-ton M. L	27.5
								6	4	B. L	.....
Ajax	Iron, 1880; type of Inflexible; protective deck, 3″ thick; condition good.	385	13.5	280 0	66 0	24 0	8,510	4	12.5	38-ton M. L	18.7
								2	6	B. L	14.1
Agamemnon	Iron, 1879; sister ship to Ajax; condition good	385	*13	280 0	66 0	24 0	8,510	4	12.5	38-ton M. L	18.7
								2	6	B. L	14.1
Conqueror	Steel, 1881; battle-ship; medium freeboard; one turret; unarmored superstructure abaft; protective deck, 2½″ to 1½″ thick, steel; one steel mast; condition good.	250	15.5	270 0	58 0	24 0	6,200	2	12	43-ton B. L	24.8
								4	6	B. L	14.1
Hero	Steel; sister ship to Conqueror; building	.....	*15.5	270 0	58 0	24 0	6,200	2	12	43-ton B. L	24.8
								4	6	B. L	14.1

*Official estimates.

A.

foreign ships of war.

Intelligence, Navy Department.)

The speed given is the highest attained with all weights and stores on board.]

ENGLAND.

Battery.	Torpedo boats.	Weight of fire.			Armor.					Backing.		Remarks.
Position and mounting.		Ahead.	Broadside.	Astern.	Distribution.	Material.	Maximum thickness.	Minimum thickness.	Skin.	Material.	Thickness.	
							In.	*In.*	*In.*		*In.*	
Two in barbette towers, two in broadside. In broadside.	.....	1,650	2,474	550	Belt complete; casemate; 2 barbette towers; conning tower; ammunition tubes.	Iron.....	11	8	1½	Teak..	10-12	One barbette tower forward, one aft, 8″ to 10″ thick; iron.
In barbette towers..... In broadside.	Two 2d cl.	1,160	1,260	1,160	Belt 139′; 4 barbettes; conning tower; ammunition tubes.	....do	10	7	1	..do ...	10	One barbette forward, one aft, one each side in waist, 8″ thick; compound. *Coal protection;* surrounding boilers and engines.
Same as Impérieuse....	....do	1,160	1,260	1,160	....do	....do	10	7	1	..do ...	10	Do.
In barbette towers..... In broadside.	....do	1,428	3,156	1,428	Belt 140′; 2 barbettes; bulkheads; conning tower; ammunition tubes.	Compound	18	8	1	..do ...	17-10	Barbette towers, 10″ to 11½″ thick; compound.
In barbette towers.... In broadside.	....do	(?)	5,300	(?)	Same as Collingwood.	....do	18	8	1	..do ...	17-10	Barbettes, 10″ to 11½″ thick; compound.
Same as Rodney	(?)	(?)	5,300	(?)	....do	....do	18	8	1	..do ...	17-10	Do.
In barbette towers.... In broadside; 2 have bow and stern fire.	One 2d cl., one picket.	2,000	4,100	2,000	Belt 150′; 2 barbettes; conning tower; ammunition tubes.	....do	18	8	1	..do ...	15-12	Barbettes, 12″ to 14″ thick; compound. *Coal protection,* 9′ thick along wing passages, 21′ thick athwartships, forward and aft of machinery.
In barbette towers..... In broadside.	Two 2d cl.	(?)	5,300	(?)	....do	... do	18	8	1	..do ...	15-12	Do.
Same as Camperdown..	(?)	(?)	5,300	(?)	....do	....do	18	8	1	..do ...	15-12	Do.
In turrets	.....	1,430	2,860	1,430	Belt complete; turrets; breastwork; conning tower.	Iron.....	12	8	1½-1¾	..do ...	16-18	Two turrets, 12″ and 14″ thick.
In forward turret..... In after turret.	Two 2d cl.	1,636	3,064	1,430	....do	...do	12	8	1½-1¾	..do ...	16-18	Do.
In turrets	.....	1,626	3,272	1,626	....do	....do	14	11	1½-1	..do ...	18-15	Two turrets, 14″ thick. *Coal protection;* protecting boilers and engines.
In turrets ..... On spar-deck.	.....	360	3,322	(?)	....do	....do	12	9	1½-1¾	..do ...	15-10	Two turrets, 13″ to 11″ thick.
In turret ..... In broadside, upper deck.	One 2d cl., one 48′ pinnace.	6,800	6,955	3,400	Belt 90′; citadel; turrets; conning tower.	....do	24	16	1	..do ...	25-17	Two turrets placed diagonally in citadel, 17″ and 16″ thick; compound. *Coal protection;* protecting boilers and engines.
In turrets ..... On superstructure, fore-and-aft fire.	.....	3,872	3,472	1,736	....do	....do	18	15	1	..do ...	18-9	Same as Inflexible, but steers very badly.
Same as Ajax.....	.....	3,872	3,472	1,736	....do	....do	18	15	1	..do ...	18-9	Do.
In turret ..... 2 on superstructure; 2 aft in superstructure, with stern fire.	.....	1,428	1,628	200	Belt complete to near stern; turret; citadel; conning tower.	Compound	12	8½	1	..do ...	13½-9	One turret forward, 12″ thick; compound. *Coal protection;* protecting boilers and engines.
In turret ..... On upper deck.	.....	.....	(?)	.....	Similar to Conqueror	....do	12	8½	1	..do ...	13½-9	Same as Conqueror. *Coal protection;* protecting boilers and engines.

Characteristics of principal

ENGLAND—Continued.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Turret armored ships—Continued.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*		
Colossus	Steel, 1882; improved type of Inflexible; two steel signal masts; protective deck, 3″ thick, steel; condition good.	396	*16.5	325 0	68 0	26 3	9,150	4	12	43-ton B. L.	.....
								2	6	B. L.	.....
								2	6	... do	.....
								1	6	... do	.....
Edinburgh	Steel, 1882; sister ship; condition good	396	*17.2	325 0	68 0	26 3	9,150	4	12	43-ton B. L.	.....
								2	6	B. L	.....
								2	6	...do	.....
								1	6	...do	.....
Renown	Steel; battle-ship; one turret; breastwork and partial belt 170′ long amidships; all protected by 18″ compound armor; transverse bulkheads at the belt ends, armor 16″ thick; superstructure containing broadside battery 150′ long is protected on sides by 3″, and at ends from raking fire by 6″ compound armor, and by traverse bulkheads between the guns 3″ thick; protective deck, extending over citadel to each end of ship 3″ thick, five above water torpedo ports and four below water; building.	430	*15.5	340 0	70 0	27 3	10,500	2	16.25	110-ton B. L.	.....
								12	6	B. L	.....
								1	9.2	.. do	.....
Sanspareil	....do	430	*15.5	340 0	70 0	27 3	10,500	2	16.25	110-ton B. L.	.....
								12	6	B. L	.....
								1	9.2	... do	.....
Casemate armored ships.											
Audacious	Iron; sheathed; 1869; battle and cruising ship; bark rig; belt and casemate; condition good.	482	13.6	280 0	54 0	23 8	6,010	4	9	M. L.	10.4
								8	4	B. L	.....
								6	9	M. L.	10.4
Invincible	....do	482	13.6	280 0	54 0	23 8	6,010	4	9	... do	10.4
								8	4	B. L.	.....
								6	9	M.L	10.4
Iron Duke	Iron, 1870; do	482	13.6	280 0	54 0	23 8	6,010	4	9	....do	10.4
								8	4	B.L	.....
								6	9	M. L	10.4
Swiftsure	Iron; sheathed; 1870; type of Audacious and class;* condition good.	473	13.75	280 0	55 0	26 1	6,910	4	9	....do	10.4
								8	4	B. L	.....
								6	9	M. L.	.....
Triumph	....do	473	13.52	280 0	55 0	26 7	6,640	4	9	... do	10.4
								8	4	B. L	.....
								6	9	M. L	.....
Sultan	Iron, 1870; battle-ship; ship rig; condition good	632	14	325 0	59 6	27 11	9,290	4	8	B. L	15.9
								7	4	... do	.....
								8	9.2	...do	17.3
Alexandra	Iron, 1875, battle-ship; ship rig; protective deck over belt, 1½″ and 1″ thick; condition good.	674	15	325 0	63 8	26 6	9,490	2	11	25-ton M. L	14
								2	10	18-ton M. L	12.8
								6	4	B. L	.....
								8	10	18-ton M. L	12.8
Superb	Iron, 1875; battle-ship; ship rig; built for Turkey; iron deck over belt, 1½″ thick; condition good.	620	13.7	332 3	59 0	26 5	9,170	4	10	....do	12.8
								6	4	B. L	.....
								12	10	18-ton M. L	12.8

* Official estimates.

Characteristics of principal

ENGLAND—Continued.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Casemate armored ships—Continued.			*Knots.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Tons.*		*Inch.*		
Belleisle	Iron, 1876; small type battle-ship; brigantine rig; built for Turkey; deck over belt, 3″, 2″, 1″, thick; condition good.	235	12.2	245 0	52 0	21 1	4,870	4	12	25-ton M. L	12.9
Orion	Iron, 1879; small type battle-ship; brigantine rig; built for Turkey; deck over belt, 3″, 2″, 1″, thick; condition good.	244	12.8	245 0	52 0	21 1	4,870	4	12	do	12.9
Belted cruisers.											
Northampton	Iron; sheathed; 1876; belted cruisers; unprotected broadside; protected from raking fire, and chase-guns protected by bulkheads with wings; bark rig; protective deck, 3″, 2″ thick, iron; condition good.	564	13.17	280 0	60 0	25 9	7,630	4 8	10 9	18-ton M. L 12-ton M. L	12. 10.
Nelson	do	556	14.05	280 0	60 0	26 6	7,630	4 8	10 9	18-ton M. L 12-ton M. L	— —
Shannon	Iron; sheathed; 1875; belted cruisers; armor on water-line; unprotected broadside; protected from raking fire by bulkhead forward; protective deck, 3″, 1½″, 1″ thick; ship rig; condition good.	454	12.35	260 0	54 0	23 6	5,390	2 1 6	10 9 9	18-ton M. L 12-ton M. L do	12. 10. —
Orlando	Steel; belted cruiser; battery unprotected; curved protective deck entire length 3″ and 2″ steel, over top of belt; dipping below water forward and aft of belt; 4 above water torpedo tubes on protective deck; train 90° from within 10° of fore and aft line; 4 fixed below water tubes in forward compartment; 2 fire 45° on bow; 2 fire abeam; 2 masts; armored tops; building; to be completed in 1887.	350	*17.5	300 0	56 0	22 6	5,000	2 10	9.2 6	18-ton B. L B. L	19 14
Undaunted	do	350	*17.5	300 0	56 0	22 6	5,000	2 10	9.2 6	18-ton B. L B. L	19 14
Australia	do	350	*17.5	300 0	56 0	22 6	5,000	2 10	9.2 6	18-ton B. L B. L	19 14
Narcissus	do	350	*17.5	300 0	56 0	22 6	5,000	2 10	9.2 6	18-ton B. L B. L	19 14
Galatea	do	350	*17.5	300 0	56 0	22 6	5,000	2 10	9.2 6	18-ton B. L B. L	19 14
Turret coast defense ships.											
Glatton	Iron, 1871; single turret; breastwork; monitor type; battle-ship for coast defense; deck, 3″ thick, iron; condition good.	185	12.11	245 0	54 0	19 3	4,910	2	12	do	12.
Cyclops	Iron, 1871; similar type (double turret); deck, 1½″ thick, iron; condition good.	157	10.7	225 0	45 0	16 4	3,480	4	10	18-ton M. L	12.
Gorgon	do	157	11	225 0	45 0	16 4	3,480	4	10	do	—
Hecate	do	157	10.6	225 0	45 0	16 4	3,480	4	10	do	—
Hydra	do	157	10.9	225 0	45 0	16 4	3,480	4	10	do	—
Rupert	Iron, 1872; breastwork turret; ram; freeboard increased by unarmored superstructure on deck; deck, 3″, 2″ thick, iron; schooner rig; condition good.	217	13	250 0	53 0	23 7	5,440	2 2	9.2 6	B. L do	17. 11.
Torpedo rams.											
Polyphemus	Steel, 1881; ram; low freeboard; turtle-back superstructure; has 5 torpedo tubes; carries 40 14″ Whitheads; condition good.	132	17.85	240 0	40 0	21 3	2,640	....	.....	Machine guns	—
Not named	Steel; similar to Polyphemus; building	150	*17.5	270 0	46 0	19 9	3,220	2	5	B. L	8
Unarmored cruisers with protective decks.											
Comus, and eight others of class.	Iron and steel; sheathed; 1878–'81; ship rig; protective deck 1½″ steel over machinery and magazines; water-tight compartments between protective deck and deck above; steel shutters for hatches; sail well; poop, top-gallant forecastle; condition good; 3 are bark rigged.	265	13 to 14	225 0	44 6	18 6 to 19 3	2,380	2 10 or 2 12	6 6 7	do do M. L 64-pdr. M. L	11. — 7 —

*Official estimates.

Characteristics of pri

ENGLAND—Continued.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.
Unarmored cruisers with protective decks—Cont'd.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*	
Heroine, and six others of class.	Steel composite, 1880–'84; bark rig; protective deck 1½" steel over boilers, &c.; 14 water-tight bulkheads; poop, and top-gallant forecastle; condition good.	159	13 to 12.5	200	38 0	15 9	1,420	2	6	B. L
								6	6	....do
									or	
								2	6	....do
								10	5	....do
Leander, and three others of class.	Steel, 1882–'83; bark rig; protective deck 1½" steel over boilers, &c.; poop and forecastle connected by fore-and-aft bridge; condition good.	267	*16	300	46 0	20 6	3,750	4	6	....do
								6	6	....do
Calypso	Steel; sheathed; 1883–'84; bark rig; protective deck 1½" steel over boilers, &c.; poop, and top-gallant forecastle; condition good.	266	*13.75	235	44 6	19 11	2,770	4	6	....do
Calliope	.....do	266	*13.75	235	44 6	19 11	2,770	12	5	....do
Mersey, and three others of class.	Steel, 1885; two signal masts; protective deck 2" and 3" steel; new type cruiser; building	250	*17	300	46 0	20 0	3,550	2	8	18-ton B. L
								10	6	B. L
Unarmored cruisers above 4,000 tons displacement.										
Inconstant	Iron; sheathed; 1868; sails well; has forecastle; no poop; ship rig; condition fair.	614	16.2	337.4	50 3	25 6	5,780	2	7	6½-ton M. L
								4	7	....do
								10	9	12-ton M. L
Shah	Iron; sheathed; 1873; has poop and forecastle; ship rig; condition good.	602	16.21	334.8	52 0	26 8	6,250	2	9	....do
								4	....	64-pdr. M. L
								2	.....	....do
								2	.....	....do
								16	7	6½-ton M. L
Raleigh	.....do	549	15.32	298	49 0	24 7	5,200	2	9	12-ton M. L
								4	6	B. L
								14	7	4½-ton M. L
Boadicea	Iron; sheathed; 1875; has poop and forecastle; ship rig; condition good.	410	14.89	280	45 0	23 8	4,140	2	7	....do
								2	.....	64-pdr. M. L
Bacchante	Iron; sheathed; 1876; has poop and forecastle; ship rig; condition good.	410	15	280	45 6	23 9	4,130	12	7	4½-ton M. L
Euryalus	Iron; sheathed; 1877; has poop and forecastle; ship rig; condition good.	410	14.7	280	45 6	23 3	4,140	....	.....	.....
Unarmored cruisers between 4,000 tons and 2,000 tons.										
Rover	Iron; sheathed; 1874; has poop and forecastle; bark rig; condition good.	335	14.53	280	43 6	23 0	3,460	2	6	B. L
								12	6	.. do
Opal, and five others of class.	Composite, 1875–'77; has poop and forecastle; ship or bark rig; condition good.	232	13.25 to 12.25	220	40 0	19 7 to 18 8	2,120	2	.....	64-pdr. M. L
								10	.....	....do
									or	
								2	6	B. L
								2	6	....do
								8	5	....do
Iris	Steel, 1877; dispatch cruiser; barkentine rig; condition good.	257	15	300	46 0	22 1	3,730	2	....	64-pdr. M. L
								4	6	B. L
								4	5	....do
Mercury	Steel, 1878; dispatch cruiser; 3 mast schooner rig; condition good.	257	*18	300	46 0	22	3,730	2	....	64-pdr. M. L
Between 2,000 tons and 1,000 tons.								8	.....	....do
Tenedos	Wood, 1870; has poop and forecastle; bark rig; condition fair.	205	12.8	212	36 0	16 10	1,760	2	.....	64-pdr. M. L
								10	.....	... do
Thetis	Wood, 1871; has poop and forecastle; ship rig; condition fair.	225	13.4	220	36 0	17 6	1,860	2	.....	....do
								12	.....	....do

*Official estimates.

foreign ships of war—Continued.

ENGLAND—Continued.

Battery.	Torpedo boats.	Weight of fire.			Armor.					Backing.		Remarks.
Position and mounting.		Ahead.	Broadside.	Astern.	Distribution.	Material.	Maximum thickness.	Minimum thickness.	Skin.	Material.	Thickness.	
							In.	*In.*	*In.*		*In.*	
Pivots		100	500	100								First three built have first battery; last four have second battery. *Coal protection;* protecting engines and boilers.
Broadside.												
Pivots		100	450	100								
Broadside.												
On sponsons, 2 forward, 2 aft.		200	500	200								*Coal protection*, about engines and boilers.
Broadside.												
Pivot, 2 forward, 2 aft		200	500	200								Do.
Broadside.												
Pivots		(†)	860	(†)								Do.
Broadside.												
In chase, on upper deck		115	1,695	115								
Broadside, upper deck.												
Broadside, on main deck												
In chase, upper deck		193	1,730	64								
Broadside, upper deck.												
In chase, upper deck.												
In chase, main deck.												
Broadside, main deck.												
Pivots, upper deck			1,521									
Broadside, upper deck.												
Broadside, main deck.												
Pivots, upper deck		64	984	64								
In chase, main deck.												
Broadside, main deck		50	940	50								Has 6″ B. L. pivots and 5″ B. L. chase.
do		64	969	64								Has two 6″ B. L., ten 7″ M. L. broadside.
Pivots		80	640	80								
Broadside.												
Pivots		90	631	90								First two of class have "Opal's" battery; last four have the second battery.
Broadside.												
Pivots		100	500	100								
Broadside.												
Do.												
Pivot	Four, 2d class.	90	480	90								*Coal protection;* protecting engines, &c., 8′ to 5′ thick.
Broadside.												
Do.												
Pivots	do	90	541	90								Do.
Broadside.												
Pivots		64	452	64								
Broadside.												
Pivots		90	722									
Broadside.												

Characteristics of principal

ENGLAND—Continued.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Between 2,000 tons and 1,000 tons—Continued.			*Knots.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Tons.*		*Inch.*		
Modeste, and four others of class.	Wood, 1873–'74; has poop and forecastle; bark or ship rig; condition good.	226	12.5 to 12.8	220	37 0	18 4 to 17 6	1,970	2	.....	64-pdr. M. L	.....
								12	.....	do	.....
									or		
								2	.....	do	.....
								10	.....	do	.....
Wild Swan, and eleven others of class.	Composite, 1876–'80; has poop and forecastle; bark rig; condition good.	138	10.0 to 11.6	170	36 0	14 3 to 14 10	1,130	2	6	B. L	11.9
								2	5	do	8.7
								4	5	do	.....
									or		
								2	7	M. L	9.7
								2	.....	64-pdr. M. L	.....
								2	.....	do	.....
Swallow, and sister ship.	Composite; barkentine rig; machinery, &c., protected by ½" steel deck; building.	82	*14.0	195	28 0	12 0	1,040	4	5	B. L	8.7
								4	5	do	.....
Gun-vessels and cruising gunboats.											
Coquette, and six others of class.	Composite, 1872–'73; barkentine rig; cruising gunboat; condition good.	60	9.7 to 10.7	125 0	22 6	10 4 to 10 11	430	2	.....	64-pdr. M. L	.....
								2	.....	20-pdr. B. L	.....
										or	
								2	5	B. L	.....
								2	4	do	.....
Frolic, and three others of class.	Composite, 1872; bark rig; cruising gunboat; condition good.	78	10.7 to 11	155 0	25 0	9 6 to 10 0	610	1	7	4½-ton M. L	.....
								1	.....	64 pdr. M. L	.....
								2	.....	20-pdr. B. L	.....
										or	
								1	6	B. L	.....
								1	5	do	.....
								2	5	do	.....
Fantome, and five others of class.	Composite, 1873–'74; bark rig; gun-vessel; condition good.	125	10.5 to 11	160 0	31 4	13 11 to 14 7	940	2	7	4½-ton M. L	.....
								2	.....	64-pdr. M. L	.....
									or		
								2	6	B. L	.....
								2	5	do	.....
Ariel	Composite, 1873; barkentine; cruising gunboat; condition good.	61	10.26	125 0	23 0	10 6	438	2	.....	94-pdr. M. L	.....
Zephyr	do	61	10.6	125 0	23 0	10 6	438	2	.....	20-pdr. B. L	.....
Arab	Composite, 1874; barkentine rig; gun-vessel; condition good.	100	10.26	150 0	28 6	13 9	720	1	7	4½-ton M. L	.....
								1	.....	64-pdr. M. L	.....
								2	.....	20-pdr. B. L	.....
Lily	do	100	10.6	150 0	28 6	13 6	720	1	6	B. L	.....
								2	5	do	.....
Cygnet, and eleven others of class.	Composite, 1874–'77; barkentine rig; cruising gunboat; condition good.	60	9 to 10.4	125 0	23 6	10 9 to 10 6	455	2	.....	64-pdr. M. L	.....
								2	.....	20-pdr. B. L	.....
									or		
								2	5	B. L	.....
								2	4	do	.....
Flamingo, and three others of class.	Composite, 1876–'77; bark rig; gun-vessel; condition good.	100	10.7 to 11	157 0	29 6	12 11 to 13 2	780	1	7	4½-ton M. L	.....
								2	.....	64-pdr. M. L	.....
Swift	Composite, 1879–'80; barkentine rig; gun-vessel; condition good.	82	11.8	165 0	29 0	10 11	756	2	7	4½-ton M. L	.....
Linnet	do	82	11.8	165 0	29 0	10 11	756	3	.....	20-pdr. B. L	.....

* Official estimates.

Characteristics of principal

ENGLAND—Continued.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Gun-vessels and cruising gunboats—Continued.			*Knots.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Tons.*		*Inch.*		
Rambler, and two others of class.	Composite, 1880; bark rig; gun-vessel; condition good.	100	10.5 to 11	157 0	29 6	13 7	835	1 2	7	4½-ton M. L..... 64-pdr. M. L.....	....
Redwing, and nine others of class.	Composite, 1880–'82; barkentine; cruising gunboats; condition good.	60	9.5 to 10	125 0	23 6	10 6 to 11 0	465	....	.....	Same as Cygent and class.	.....
Dolphin.....	Composite, 1882; bark rig; gun-vessel; condition good.	110	10.5	157 0	32 0	14 0	925	2	6	B. L.....	10.5
Wanderer.....	Composite, 1883; bark rig; gun-vessel; condition good.	110	10.5	157 0	32 0	14 0	925	2	5	... do.....	8.7
Albacore, and two others of class.	Composite, 1883; barkentine; cruising gunboat; condition good.	60	11	135 0	26 0	11 6	560	2 2	5 4	....do..... ....do.....	8.7 6.7
Reindeer, and five others of class.	Composite, 1883–'85; bark rig; gun-vessel; condition good.	100	*11 to *13.5	167 0	32 0	14 0	970	2 4 4 4	5 5 or 5 5	....do..... ....do..... ....do..... ... do.....	8.7 8.7 8.7 8.7
Curlew.....	Steel; gun and torpedo-vessel; building; cruisers in time of peace.	90	*14	195 0	28 0	11 0	785	1	6	....do.....	10.5
Landrail.....		90	*14	195 0	28 0	11 0	785	3	5	....do.....	8.7
Gunboats for coast and river service.											
Staunch.....	Iron, 1867; gun mounted in bow on platform, which lowers into hold at sea, and is raised by screws for action; bullet-proof shield; condition good.	25	7.65	75 0	25 0	6 9	180	1	9	12-ton M. L.....	10.4
Plucky.....	Iron, 1870; gun mounted in bow on platform, which lowers into hold at sea, and is raised by screws for action; bullet-proof shield; condition good.	25	8.58	80 0	25 1½	6 1	195	1	9	12-ton M. L.....	10.4
Blazer, and nineteen others of class.	Iron, 1870–'73; gun mounted in bow on platform, which lowers into hold at sea, and is raised by screws for action; bullet-proof shield; condition good.	25	8 to 8.7	85 0	26 1½	6 6	254	1 1	9.2 or 10	B. L..... or 18-ton M. L.....	17.3 12.8
Medina, and eleven others of class.	Iron, 1876–'77; double-ender, bow rudder; poop and forecastle; 3 light schooner-rig masts; river and harbor service; fair sea boats; condition good.	46	9.3 to 9.9	110 0	34 0	6 0	363	3	.....	64-pdr. M. L.....	.....
Gadfly, and five others of class.	Iron, 1879–'81; type of Staunch, condition good.....	25	8.3	85 0	26 1½	6 7	265	1	10	18-ton M. L.....	12.8
Torpedo vessels.											
Hecla.....	Iron; torpedo depot and transporting ship; formerly merchant steamer; 4 masts; condition good.	246	11.7	391 7	38 9	24 3	6,400	1 4 1	....	64-pdr. M. L..... ....do..... 40-pdr. B. L.....	....
Vesuvius.....	Iron, 1874; torpedo instruction vessel; 1 under-water bow tube; 4 above-water carriages; condition fair.	17	9.7	90 0	22 0	8 6	245	....	†	.....	.....
Scout..... / Fearless.....	Steel; torpedo cruisers; schooner rig; 10 above-water torpedo tubes; 1 submerged bow tube; steel deck ⅜-inch over machinery; building.	130	*16	220 0	34 0	14 6	1,430	4	5	B. L.....	8.7
Archer, and six others of class.	Steel; type of Scout; protective deck entire length; 8 above-water torpedo tubes; 1 submerged bow tube; building.	140	*16	225 0	36 0	14 6	1,600	6	6	B. L.....	10.5

*Official estimate.

foreign ships of war—Continued.

ENGLAND—Continued.

Battery.	Torpedo boats.	Weight of fire.			Armor.					Backing.		Remarks.
Position and mounting.		Ahead.	Broadside.	Astern.	Distribution.	Material.	Maximum thickness.	Minimum thickness.	Skin.	Material.	Thickness.	
							In.	*In.*	*In.*		*In.*	
Pivot			295									
Do.												
Same as Cygnet and class.		20	169	20								Seven have Cygnet's battery; three have second battery.
Pivot		100	300	100								
Do.												
Pivot			150									
Do.												
Pivot		50	200	50								Five have the second battery.
Broadside.												
On sponsons, 2 forward, 2 aft.		100	200	100								
Broadside.												
(?)												Carry 10 Whitehead torpedoes above water, discharging tubes.
(?)												
Trained by helm		258										Gunboats of this type when attached to the "Particular service squadron" were found to have a maximum sea speed of 4 knots. When towed at a speed greater than 8 knots they shipped such quantities of water as to be in danger of foundering.
do		258										Do.
do		320										Do.
do		410										
2 under forecastle, 1 under poop.		129 180	129 or 180	64 90								Do.
Trained by helm		410										Do.
Pivot	Eight 2d cl.		233									Carries 30 Whiteheads.
Broadside.												
Pivot.												
												Carries 8 Whiteheads.
On sponsons, 2 forward, 2 aft.		100	100	100								*Coal protection;* 5′ to 6′ thick in wake of machinery.
On sponsons, 2 forward, 2 aft, 2 in waist.		200	300	200								*Coal protection;* 5′ to 7′ thick in wake of machinery.

Characteristics of principal

FRANCE.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Battle ships, armored fleet.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*		
Friedland	Iron, 1873; battle-ship; belt, casemate, and unarmored barbette towers; protective deck 3.15″ thick; ship rig; condition good.	700	13.3	317 0	58 0	29 11	8,916	6	10⅝	B. L	16.81
								2	10⅝	....do	.....
								8	5½	....do	.....
Trident	Wood, 1876; similar to Friedland, but no protective deck; ship rig; condition good.	774	14.2	317 9	57 10	29 10	8,814	6	10⅝	....do	16.81
								2	10⅝	....do	.....
								6	5½	....do	.....
								2	9½	....do	13.31
Colbert	Wood, 1875; similar to Friedland, but no protective deck; ship rig; condition good.	702	14.5	317 9	57 10	28 6	8,617	6	10⅝	....do	16.81
								2	10⅝	....do	.....
								6	5½	....do	.....
								2	9½	....do	.....
Redoutable	Iron and steel, 1876; similar to Friedland; deck 1.6″ to 2.36″ thick; ship rig; condition good.	700	14.7	318 6	64 6	24 10	8,800	4	10⅝	....do	16.81
								2	10⅝	....do	.....
								2	10⅝	....do	.....
								6	5½	....do	.....
Dévastation	Iron and steel, 1879; similar to Friedland; deck 2.36″ thick; ship rig; condition good.	600	15.2	311 7	69 8	24 11	9,639	4	13½	47-ton B. L	22.01
								2	10⅝	B. L	16.81
								6	5½	....do	.....
Foudroyant (now named Courbet).	Iron and steel, 1881; sister ship to Dévastation; ship rig; condition good.	600	14.2	311 7	69 8	24 11	9,609	4	13½	47-ton B. L	22.01
								2	10⅝	B. L	16.81
								6	5½	Do.	
Richelieu	Wood, 1873; battle ship; belt, casemate, and armored barbette towers; protective deck 4.3″ thick; ship rig; condition good.	750	13.1	322 7	57 10	27 10	8,790	6	10⅝	....do	16.81
								4	9½	....do	13.31
								1	9½	....do	.....
								7	5½	....do	.....
								1	4¼	....do	.....
Amiral Duperré	Iron and steel, 1879; battle-ship; belt, armored barbette towers; unprotected broadside; protective deck 2.36″ thick; three masts, armored tops; condition good.	850	14.5	319 10	66 11	26 9	10,487	4	13½	47-ton B. L	22.01
								15	5½	B. L	.....
Amiral Baudin	Iron and steel; sheathed; 1883; same general type as Amiral Duperré; protective deck 3.15″ thick; one mast, armored top; ram; condition good.	500	*15	321 6	69 0	26 0	11,441	3	16½	74-ton B. L	33.47
								12	5½	B. L.	
Formidable	Steel, 1885; sister ship to Amiral Baudin; two masts, armored tops; condition good.	500	*15	321 6	69 0	26 0	11,441	3	16½	74-ton B. L	33.47
								12	5½	B. L.	
Marceau	Iron and steel, 1884; type of Amiral Duperré; protective deck 3.15″ thick; completing.	.....	*16	330 0	65 6	27 3	10,581	2	13½	B. L	22.01
								2	10⅝	....do	16.81
								2	5½	....do	.....
								18	5½	....do	.....
Hoche	Iron and steel; sister ship to Marceau; not launched.	.....	*16	330 0	65 6	27 3	10,581	2	13½	....do	22.01
								2	10⅝	....do	16.81
								2	5½	Do.	
								18	5½	Do.	
Magenta	.....do	.....	*16	330 0	65 6	27 3	10,581	2	13½	....do	22.01
								2	10⅝	....do	16.81
								2	5½	Do.	
								18	5½	Do.	
Neptune	.....do	.....	*16	330 0	65 6	27 3	10,581	2	13½	....do	22.01
								2	10⅝	....do	16.81
								2	5½	Do.	
								18	5½	Do.	

* Official estimate.

foreign ships of war—Continued.

FRANCE.

Battery.	Torpedo boats.	Weight of fire.			Armor.					Backing.		Remarks.
Position and mounting.		Ahead.	Broadside.	Astern.	Distribution.	Material.	Maximum thickness.	Minimum thickness.	Skin.	Material.	Thickness.	
							In.	*In.*	*In.*		*In.*	
In casemate In barbette, ½ towers. In broadside.		950	2,038	950	Belt entire length; casemate.	Iron	9	8½		Wood.	25⅝–12⅝	Two barbettes abreast and forward of smoke-pipe, elliptical half towers.
In casemate In barbette towers. In broadside. 1 in bow, 1 stern.		1,267	2,084	1,267	do	do	8⅝	6½		Teak	14⅝–24⅝	Two barbettes abreast smoke-pipe, one on each side.
Same as Trident		1,267	2,084	1,267	Belt entire length casemate.	Iron	8⅝	6½		Teak	14⅝–24⅝	Two barbettes abreast smoke-pipe, one on each side.
In casemate In barbettes. 1 in bow, 1 stern. In broadside.		2,375	1,613	2,462	do	do	14	10½		do	15	Do.
In casemate In barbette. In broadside, 2 have stern fire.		2,804	2,467	1,042	Belt stopping 28′ short of stern; redoubt; bulkheads.	do	15	8⅝	1½	do	12⅝	Do.
Same as Dévastation		2,804	2,467	1,042	do	do	15	8⅝	1½	do	12⅝	Do.
In casemate In barbette, ½ towers. In bow. In broadside. Do.		951	2,242	634	Belt entire length; casemate, and 4 barbette ½ towers.	do	8⅝	7½		Wood.	14.7-24.4	Half towers, 6.3″ thick, one on each corner of casemate.
In barbettes In broadside.		1,854	3,059	973	Belt entire length; 4 barbette towers.	do	21.6	10	1.5	do	14½	Barbettes 11.8″ thick; 1 aft, 1 in waist, 1 each side, forward of smoke-pipe.
In barbette In broadside.					Belt entire length; 3 barbette towers.	Steel	21.6	13.75		Teak	13¾	Barbettes 16½′ steel; 2 forward, 1 aft.
do					do	do	21.6	13.75		do	13¾	Do.
In barbette; one forward, one aft. In barbette; one each side. On forecastle. In broadside.		2,001	2,945	1,878	Similar to Amiral Duperré.	Compound	17.75	13.75		do	13¾	Barbettes 15¾″ steel; 1 aft, 1 forward, 1 each side in waist.
Same as Marceau		2,001	2,945	1,878	do	do	17.75	13.75		do	13¾	Do.
do		2,001	2,945	1,878	do	do	17.75	13.75		do	13¾	Do.
do		2,001	2,945	1,878	do	do	17.75	13.75		do	13¾	Do.

Characteristics of principal

FRANCE—Continued.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Battle ships, armored fleet—Continued.			*Knots.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Tons.*		*Inch.*		
Charles Martel	Steel; protective deck 3.54″ thick; type not known; not launched.	(?500)	*15	344 6	64 0	26 8	9,780	4	13½	B. L	22.01
								8	5½	....do	
Brennus	....do	(?500)	*15	344 6	64 0	26 8	9,780	4	13½	....do	22.01
								8	5½		
Terrible	Iron and steel, 1881; high freeboard barbette battleship; one barbette forward, one aft; armored deck 3.15″ thick; two masts, armored tops; intended chiefly for coast defense; ram; completing.	300	14.5	271 7	59 0	24 7	7,184	2	16½	74-ton B. L	33.47
								4	4	B. L	
Requin	Iron and steel, 1885; high freeboard barbette battleship; one barbette forward, one aft; armored deck 3.15″ thick; two masts, armored tops; intended chiefly for coast defense; ram; completing.	300	*14.5	271 7	59 0	24 7	7,184	2	16½	74-ton B. L	33.47
								4	4	B. L	
Indomptable	Iron and steel, 1883; high freeboard barbette battleship; one barbette forward, one aft; armored deck 3.15″ thick; two masts, armored tops; intended chiefly for coast defense; ram; completing.	300	*14.5	271 7	59 0	24 7	7,184	2	16½	....do	33.47
								4	4	....do	
Caiman	Iron and steel, 1885; high freeboard barbette battleship; one barbette forward, one aft; armored deck 3.15″ thick; two masts, armored tops; intended chiefly for coast defense; ram; completing.	300	*14.5	278 2	59 0	24 7	7,239	2	16½	....do	33.47
								4	4	....do	
Turret, coast-defense ships.											
Tonnerre	Iron and steel, 1875; mastless turret battle-ship, armored breastwork, surmounted by unarmored superstructure; armored deck 2″ thick; ram; condition good.	190	14	241 6	57 9	21 4	5,580	2	10⅝	23-ton B. L	16.81
								4	4¾	B. L	
Fulminante	Iron and steel, 1877; mastless turret battle-ship; armored breastwork, surmounted by unarmored superstructure; armored deck 2″ thick; ram; condition good.	190	13.2	248 0	57 8	21 4	5,584	2	10⅝	23-ton B. L	16.81
								4	4¾	B. L	
Furieux	Iron and steel, 1883; mastless turret battle-ship; armored breastwork, surmounted by unarmored superstructure; armored deck 3.15″ to 3.54″ thick; ram; condition good.	163	*13	246 0	58 4	21 4	5,695	2	13½	....do	22.01
Tempête	Iron and steel, 1876; type of Tonnerre, but smaller, for local coast defense; armored deck 2″ thick; ram; condition good.	163	12.8	241 6	57 9	16 9	4,523	2	10⅝	....do	16.81
Vengeur	Iron, 1878; type of Tonnerre, but smaller, for local coast defense; armored deck 2″ thick; ram; condition good.	163	13.75	241 6	57 9	16 9	4,523	2	10⅝	....do	16.81
Tonnant	Iron and steel, 1880; type of Tonnerre, but smaller, for local coast defense; armored deck 3.15″ thick; ram; condition good.	163	12.8	241 6	57 9	16 9	4,523	2	10⅝	....do	16.81
Tigre	Wood, 1871; mastless single turret; low freeboard, coast-defense vessel; iron turtle back; ram; condition poor.	150	12	216 6	53 1	19 7	3,703	2	9½	....do	13.31
Bouledogue	Wood, 1872; mastless single turret; low freeboard; coast-defense vessel; iron turtle back; ram; condition poor.	150	12	216 6	53 1	19 7	3,703	2	9½	....do	13.31
Armored cruisers.											
La Galissonnière	Wood, 1872; cruiser; casemate and armored barbette towers; ship rig; ram; condition good.	346	13	255 10	49 2	23 10	4,487	4	9½	....do	13.31
								2	9½	....do	
								6	3⅝	....do	
Victorieuse	Wood, 1875; similar type; condition good	367	12.75	258 2	48 9	22 8	4,504	4	9½	....do	13.31
								2	9½	....do	
								1	7½	....do	7.95
								6	5½	....do	
Triomphante	Wood, 1877; similar type; protective deck 2″ thick; condition good.	367	12.9	258 2	48 9	22 8	4,127	4	9½	....do	13.31
								2	9½	....do	
								1	7½	....do	7.95
								6	5½	....do	
								1	4 7/10	....do	
Thétis	Wood, 1877; similar type, but smaller; deck 2″ thick; condition good.	313	12	230 0	46 4	21 10	3,621	4	7½	....do	7.95
								2	7½	....do	
								6	3⅝	....do	

*Official estimates.

Characteristics of principal

FRANCE—Continued.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimension. Length.	Dimension. Breadth.	Dimension. Draught aft.	Dimension. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle.)
Armored cruisers—Con'd.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*		
Turenne	Wood, 1879; cruiser; belt; armored barbette towers; unprotected broadside; deck 2″ thick; ship rig; ram; condition good.	450	14.1	265 9	57 2	24 10	5,881	4	9⅛	B. L.	13.31
								1	7⅛	do	7.95
								1	7⅛	do	
								6	5½	do	
Bayard	Wood, 1880; sister ship; condition good	450	14.1	265 9	57 2	24 10	5,881	4	9⅛	do	13.31
								1	7⅛	do	7.95
								1	7⅛	Do.	
								6	5½	Do.	
Duguesclin	Iron; sheathed; 1883; similar type to Turenne; deck 2″ thick; condition good.	450	14	265 8	57 2	25 3	5,869	4	9⅛	do	13.31
								1	7⅛	do	7.95
								1	4 7/10	Do.	
								6	5½	Do.	
Vauban	Iron; sheathed; 1883; sister ship to Duguesclin; ram; condition good.	450	14	265 8	57 2	25 3	5,869	4	9⅛	do	13.31
								1	7⅛	do	7.95
								1	4.7		
								6	5½		
Armored gun-vessels.											
Achéron	Steel, 1885; armored gun-vessel; one signal mast; guns protected from machine-gun fire; one barbette forward; ram; condition good.	.....	*13	181 0	39 4	11 10	1,639	1	10.63	do	16.26
								2	3.94	do	
Cocyte	Building; sister vessel to Achéron	.....	*13	181 0	39 4	11 10	1,639	1	10.63	do	
								2	3.94	Do.	
Phlégéton	do	.....	*13	181 0	39 4	11 10	1,639	1	10.63	do	
								2	3.94	Do.	
Styx	do	.....	*13	181 0	39 4	11 10	1,639	1	10.63	do	
								2	3.94	Do.	
Fusée	Steel, 1884; similar type, but smaller; ram; condition good.	.....	*13	165 0	32 7	10 4	1,045	1	10.63	do	16.26
								1	3.54	do	
Grenade	1885; sister vessel to Fusée	.....	*13	165 0	32 7	10 4	1,045	1	10.63	do	
								1	3.54	Do.	
Mitraille	do	.....	*13	165 0	32 7	10 4	1,045	1	10.63	do	
								1	3.54	Do.	
Flamme	do	.....	*13	165 0	32 7	10 4	1,045	1	10.63	do	
								1	3.54	Do.	
Unarmored cruisers above 4,000 tons displacement.											
Tourville	Iron; sheathed; 1876; new type; 1st-class cruiser; ship rig; ram; condition good.	550	16.89	326 8	50 0	25 3	5,522	14	5½	do	7.95
								7	7⅛	do	
Duquesne	Iron; sheathed; 1876; sister ship; ram; condition good.	550	16.89	326 8	50 0	25 3	5,522	14	5½	do	
								7	7⅛	Do.	
Sfax	Steel, 1884; new type; 1st-class cruiser; ship rig; protective deck, 1½″ steel; ram; condition good.	.....	16.5	288 8	49 2	24 8	4,488	6	6.3	do	8.31
								10	5.51	do	
Cruisers between 2,000 tons and 4,000 tons.											
La Pérouse	Wood, 1877; new type; 2d-class cruiser; ship rig; condition good.	264	14.73	262 6	37 5	18 8	2,257	3	5.51	do	
								12	5.51	do	
Neilly	Wood, 1880; condition good	264	15.5	262 6	37 5	18 8	2,257	3	5.51	do	
								12	5.51	Do.	
Primauguet	Wood, 1882; condition good	264	15.4	262 6	37 5	18 8	2,257	3	5.51	do	
								12	5.51	Do.	
D'Estaing	Wood, 1879; condition good	264	15.3	262 6	37 5	18 8	2,257	3	5.51	do	
								12	5.51	Do.	

*Official estimates.

foreign ships of war—Continued.

FRANCE—Continued.

Battery.	Torpedo boats.	Weight of fire.			Armor.					Backing.		Remarks.
Position and mounting.		Ahead.	Broadside.	Astern.	Distribution.	Material.	Maximum thickness.	Minimum thickness.	Skin.	Material.	Thickness.	
							In.	*In.*	*In.*		*In.*	
In barbette		799	1,135	317	Belt entire length; 4 barbette towers.	Iron	9⅞	6⅛		Teak	15	Barbettes similar to Amiral Duperré, 7.9″ thick.
In bow.												
In stern.												
In broadside.												
Same as Turenne		799	1,135	317	do	do	9⅞	6⅛		do	15	Do.
do		799	1,069	317	do	do	9⅞	6⅛	1⅛	do	15	Similar to Amiral Duperré, barbettes, 8″ thick.
do		799	1,069	317	do	do	9⅞	6⅛	1⅛	do	15	Do.
In barbette tower forward.		525	500	50	Belt complete and barbette tower.		9.5					Barbette armor 4″.
In sponsons.												
do		525	500	50	do		9.5					Do.
do		525	500	50	do		9.5					Do.
do		525	500	50	do		9.5					Do.
In barbette tower forward.		475	495	20	Belt complete and barbette tower.		9.45	7.1				Do.
Aft.												
do		475	495	20	do		9.45	7.1				Do.
do		475	495	20	do		9.45	7.1				Do.
do		475	495	20	do		9.45	7.1				Do.
In broadside, gun-deck		495	925	330								
On spar-deck, three each side in sponsons, one in bow.												
Same as Tourville		495	925	330								
On spar-deck, four on sponsons.		396	605	198								*Coal protection*; between protective deck and deck above.
On gun-deck, in broadside.												
Pivots, two bow, one stern.		123	492	61.6								
Broadside.												
Same as La Pérouse		123	492	61.6								
do		123	492	61.6								
do		123	492	61.6								

Characteristics of principal

FRANCE—Continued.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Powers (inches of wrought iron at muzzle).
Cruisers between 2,000 tons and 4,000 tons—Cont'd.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*		
Forfait	Wood, 1879; new type; 2d-class cruiser; ship rig; ram; condition good.	263	15.5	249 4	38 0	17 3	2,268	3	5.51	B. L	
								12	5.51	Do.	
Villars	Wood, 1879; condition good	263	14.3	249 4	38 0	17 3	2,268	3	5.51	do	
								12	5.51	Do.	
Roland	Wood, 1882; condition good	263	15.5	249 4	38 0	17 3	2,268	3	5.51	do	
								12	5.51	Do.	
Magon	Wood, 1881; condition good	263	14.35	249 4	38 0	17 3	2,268	3	5.51	do	
								12	5.51	Do.	
Duguay-Trouin	Iron, 1879; iron hull, sheathed with teak; new type cruiser; ship rig; condition good.	311	15.9	290 0	42 8	20 6	3,289	5	7.48	do	7.95
								1	5.51	do	
								4	5.51	do	
Iphigénie	Wood, 1881; new type; 2d-class cruiser; ship rig; ram; condition good.		15	240 0	46 7	22 4	3,192	2	6.3	do	8.31
								18	5.51	do	
Naïde	do	445	13.68	244 4	46 5	23 0	3,284	2	6.3	do	8.31
								2	5.51	do	
								16	5.51	do	
Aréthuse	Wood, 1882; new type; 2d-class cruiser; ship rig; ram; condition good.		16	277 6	43 6	21 7	3,356	4	6.3	do	8.31
								23	5.51	do	
Dubordieu	Wood, 1884; new type; 2d-class cruiser; ship rig; ram; condition good.	450	14.5	253 6	46 6	22 8	3,355	4	6.3	do	8.31
								22	5.51	do	
Unarmored cruisers between 2,000 tons and 1,000 tons.											
Champlain	Wood, 1872; old type cruiser; double ender; flush deck; bark rig; condition good.	208	14.3	259 0	35 10	18 9	1,940	1	6.3	do	
								1	5.51	do	
								8	5.51	do	
Du-Petit-Thouars	Wood, 1874; old type cruiser; double ender; flush deck; bark rig; condition good.	206	15	262 4	35 9	18 8	1,962	2	5.51	do	
								8	5.51	do	
Sané	Wood, 1870; old type cruiser; bark rig; condition good.	202	15	256 0	36 1	18 4	1,915	6	5.51	do	
Seignelay	Wood, 1874; sister ship; condition good	202	15	256 0	36 1	18 4	1,915	2	5.51	do	
								6	5.51	do	
Vaudreuil	Wood, 1870; old type cruiser; third class; bark rig; condition good.	156	10.77	204 8	34 1	16 1	1,244	6	5.51	do	
Beautemps Beaupré	Wood, 1872; old type cruiser; third class; bark rig; condition good.	154	12.6	204 8	34 1	15 6	1,255	1	6.3	do	
								5	5.51	do	
Duchaffaut	do	154	12.7	204 8	34 1	15 6	1,262	6	5.51	do	
Hugon	do	155	11.7	204 8	34 1	15 11	1,262	1	6.3	do	
								5	5.51	do	
Kerguelen	do	155	12.7	204 8	34 1	15 11	1,262	2	5.51	do	
								4	5.51	do	
La Clocheterie	Wood, 1872; cruiser; double ender; flush deck; bark; condition good.	210	13.7	262 4	35 9	18 8	1,994	12	5.51	do	
Fabert	Wood, 1874; cruiser; third class; bark rig; condition good.	218	14.9	256 0	36 1	18 4	1,927	2	5.51	do	
								6	5.51	do	
Rigault de Genouilly	Wood and iron, 1876; cruiser; third class; new type; bark; ram; condition good.	198	14.5	236 2	35 5	17 1	1,643	2	5.51	do	
								6	5.51	do	
Éclaireur	Wood and iron, 1877; cruiser; third class; new type; bark; ram; condition good.	195	15	236 6	35 5	17 0	1,658	2	5.51	do	
								6	5.51	Do.	

Foreign ships of war—Continued.

FRANCE—Continued.

Battery.	Torpedo boats.	Weight of fire.			Armor.					Backing.		Remarks.
Position and mounting.		Ahead.	Broadside.	Astern.	Distribution.	Material.	Maximum thickness.	Minimum thickness.	Skin.	Material.	Thickness.	
							In.	*In.*	*In.*		*In.*	
Same as La Pérouse		123	492	61.6								
— do		123	492	61.6								
— do		123	492	61.6								
— do		123	492	61.6								
One in bow, four on sponsons.		495	511.5	391.5								
In stern.												
Broadside.												
On spar deck		198	653	198								
Broadside gun deck.												
On spar deck		198	715	123								
Do.												
Broadside, gun deck.												
Spar deck, on sponsons		258(?)	975.6	198								
Broadside, gun deck.												
Spar deck, on sponsons		198	875.6	198								
Broadside, gun deck.												
In bow		100	246	61.5								
In stern.												
Broadside.												
One bow; one stern		61.5	369.6	61.5								
Broadside.												
(?)			(?)									
One bow; one stern		61.5	308	61.6								
Broadside.												
(?)			(?)									
Pivot												
(?)			(?)									
(?)			(?)									
(?)			(?)									
Pivots, one forward t. g. forecastle, one on quarter deck.			(?)									
Broadside.												
Ten broadside; two pivots, one forward, one aft.			431									
Two pivots, one forward, one aft.		61.6	308	61.6								
Broadside.												
Pivots, one t. g. f. c., one on poop.		61.6	308	61.6								
Broadside.												
Same as Rigault de Genouilly.		61.6	308	61.6								

Characteristics of principal

FRANCE—Continued.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Unarmored cruisers between 2,000 tons and 1,000 tons—Cont'd.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*		
Milan	Steel, 1884; new type; rapid torpedo cruiser; three light fore and aft rigged masts; ram; condition good.	.....	18.4	303 0	32 10	12 9	1,546	5	3.94	B. L	.....
Unarmored gun-vessels and cruising gunboats.											
Crocodile	Composite, 1874; cruising gunboat; bark rig; ram; condition good.	60	9.65	141 9	23 11	9 4	466	2	5.51	....do	.....
Lionne	Wood, 1874; cruising gunboat; bark rig; ram; condition good.	60	9.8	141 8	23 11	9 6	464	1 2	5.51 1.57	....do	.....
Boursaint	Wood, 1872; gun-vessel; bark rig; stump top-gallant masts; ram; condition good.	88	11.5	198 6	28 0	12 8	763	2 1	5.51 6.3	....do ....do	.....
Bisson	Wood, 1874; gun-vessel; bark rig; stump top-gallant masts; ram; condition good.	106	11.78	199 6	28 5	12 9	823	4	5.51	....do	.....
La Bourdonnais	Wood, 1877; gun-vessel; bark rig; stump top-gallant masts; ram; condition good.	105	11.69	199 6	28 5	12 9	823	4	5.51	....do	.....
Chasseur	Wood, 1878; gun-vessel; bark rig; stump top-gallant masts; ram; condition good.	106	11	199 6	28 5	12 9	811	4	5.51	....do	.....
Voltigeur	.....do	106	12.48	199 6	28 5	12 9	811	4	5.51	....do	.....
Inconstant	Wood; gun-vessel; bark rig; stump top-gallant masts; ram; building.	106	.....	199 6	27 5	12 9	811	4	5.51	....do	.....
Papin	.....do	106	.....	199 6	28 5	12 9	811	4	5.51	....do	.....
Fulton	.....do	106	.....	199 6	28 5	12 9	811	4	5.51	... do	.....
Hussard	Wood, 1875; gun-vessel; bark rig; stump top-gallant masts; ram; condition good.	107	12	201 10	28 6	13 8	825	4	5.51	... do	.....
Dumont d'Urville	Wood, 1878; gun-vessel; bark rig; stump top-gallant masts; ram; condition good.	108	11.6	201 10	28 6	13 8	825	4	5.51	....do	.....
Bouvet	Wood, 1876; gun-vessel; bark rig; ram; condition good.	105	11.39	197 7	28 1	12 10	748	3 1	5.51 3.54	....do ....do	.....
Parseval	Wood, 1879; gun-vessel; bark rig; ram; condition good.	105	12.33	197 7	28 1	12 10	748	3 1	5.51 3.54	....do Do.	.....
Lutin	Composite, 1877; cruising gunboat; barkentine rig; ram; condition good.	78	10	144 8	23 11	9 4	474	2 2	5.51 3.94	.....	.....
Lynx	Composite, 1878; cruising gunboat; barkentine rig; ram; condition good.	78	10.3	144 8	23 11	9 4	474	2 2	5.51 3.94	.....	.....
Aspic	Composite, 1880; cruising gunboat; barkentine rig; condition good.	77	10.3	145 4	23 11	9 10	463	2 2	5.51 3.94	.....	.....
Vipère	Composite, 1881; cruising gunboat; barkentine rig; condition good.	77	10.3	145 4	23 11	9 10	463	2 2	5.51 3.94	.....	.....
Volage	Wood, 1881; cruising gunboat; barkentine rig; condition good.	78	10.76	160 5	28 2	11 8	422	2	7.48	B. L	7.95
Sagittaire	.....do	77	11	148 4	23 11	9 6	450	2 2	5.51 3.94	....do ....do	.....
Capricorne	Wood, 1882; cruising gunboat; barkentine rig; condition good.	77	11.2	148 4	23 11	9 6	450	2 2	5.51 3.94	....do	.....
Comète	Wood, 1884; cruising gunboat; barkentine rig; condition good.	77	11	151 6	24 9	10 6	473	2 2	5.51 3.94	....do	.....
Gabes	.....do	77	11	151 6	24 9	10 6	473	2 2	5.51 3.94	....do	.....
Lion	.....do	77	11	151 6	24 9	10 6	473	2 2	5.51 3.94	....do	.....
Scorpion	.....do	77	11	151 6	24 9	10 6	473	2 2	5.51 3.94	....do	.....
Météore	Wood, 1884; cruising gunboat; barkentine rig; building.	77	11	151 6	24 9	10 6	473	2 2	5.51 3.94	....do	.....
Étoile	Composite; building	.....	.....	149 2	24 7	8 4	448	.....	.....	.....	.....

* Official estimates.

foreign ships of war—Continued.

FRANCE—Continued.

Battery.		Weight of fire.			Armor.					Backing.		Remarks.
Position and mounting.	Torpedo boats.	Ahead.	Broadside.	Astern.	Distribution.	Material.	Maximum thickness.	Minimum thickness.	Skin.	Material.	Thickness.	
							In.	In.	In.		In.	
One bow; one stern; three shifting broadside.		25	125	25								
(?)			123									
(?)			61.6									
Pivots		61.6	222									
Pivot in bow.												
One bow; one stern; two pivots.		61.6	246.4	61.6								
do		61.6	246.4	61.6								
do		61.6	246.4	61.6								
do		61.6	246.4	61.6								
do		61.6	246.4	61.6								
do		61.6	246.4	61.6								
do		61.6	246.4	61.6								
do		61.6	246.4	61.6								
do		61.6	246.4	61.6								
Pivots, one on poop		20	204	61.6								
Pivot on top-gallant forecastle.												
do		61.6	204	20								
Pivots, amidships		25	173	25								
One on top-gallant forecastle, one on poop.												
do		25	173	25								
do		25	173	25								
do		25	173	25								
Pivots			330									
Pivots, amidships		25	173	25								
Pivots, one on top-gallant forecastle, one on poop.												
Same as Sagittaire		25	173	25								
do		25	173	25								
do		25	173	25								
do		25	173	25								
do		25	173	25								
do		25	173	25								

Characteristics of principal

FRANCE—Continued.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Breadth.	Draught aft.	Displacement.	Battery. Number.	Caliber.	Type.	Power (inches of wrought-iron at muzzle).
Special river service gunboats.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*		
Alerte and seven others of class.	Steel, 1883–'84; double-enders; screw; built in France for service in rivers of Tonquin; sent out in sections; condition good.	.....	9 to 8.5	98 to 105	19 0	4 0	.....	3	3.54	B. L.	.....
Torpedo cruisers.											
Condor	Steel, 1885; three light fore and aft rigged pole masts; five torpedo launching tubes, two ahead, one astern, one each beam; ram; condition good.	.....	*17	216 0	29 2	15 5	1,272	5	3.94	do	.....
Epervier	Building; sister vessel to Condor	.....	*17	216 0	29 2	15 5	1,272	5	3.94	do	.....
Faucon	do	.....	*17	216 0	29 2	15 5	1,272	5	3.94	do	.....
Vautour	do	.....	*17	216 0	29 2	15 5	1,272	5	3.94	do	.....
Torpedo dispatch vessels.											
Bombe	Steel, 1885; three light fore and aft rigged pole masts; two torpedo launching tubes ahead; ram; condition good.	.....	*18	180 0	21 6	6 0	321	2	4.72	do	.....
Couleuvrine	Building; sister vessel to Bombe	.....	*18	180 0	21 6	6 0	321	2	4.72	do	.....
Dague	do	.....	*18	180 0	21 6	6 0	321	2	4.72	do	.....
Dragonne	do	.....	*18	180 0	21 6	6 0	321	2	4.72	do	.....
Flèche	do	.....	*18	180 0	21 6	6 0	321	2	4.72	do	.....
Lance	do	.....	*18	180 0	21 6	6 0	321	2	4.72	do	.....
Sainte-Barbe	do	.....	*18	180 0	21 6	6 0	321	2	4.72	do	.....
Salve	do	.....	*18	180 0	21 6	6 0	321	2	4.72	do	.....

ITALY.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Breadth.	Draught aft.	Displacement.	Battery. Number.	Caliber.	Type.	Power (inches of wrought-iron at muzzle).
Armored battle ships											
Duilio	Iron and steel, 1876; battle-ship; two turrets; unarmored ends; protective deck, 2″ thick; one mast with military top; belt 147′ long, surmounted by citadel 108′ long; athwart-ship bulkheads; condition good.	406	15.04	339 6	64 9	28	11,438	4 6	17.72 4.72	100-ton M. L.	31.69
Dandolo	Iron and steel, 1878; similar type to Duilio; ram; condition good.	406	15.05	339 6	64 9	28 9	11,225	4 6	17.72 4.72	do	31.60
Italia	Steel, 1880; battle ship; one large elliptical barbette redoubt; six smoke pipes; light guns unprotected; protective deck, 3″ thick; two masts with military tops; no armor on sides at water-line; ram; condition good.	431	*17	400	73 9	30 6	13,898	4 12 6	16.93 6	100-ton B. L. B. L. Light guns	34.8 7.87 .....
Lepanto	Steel, 1883; battle-ship; one large elliptical barbette redoubt; six smoke-pipes; light guns unprotected; protective deck, 3″ thick; two masts with military tops; no armor on sides at water-line; ram; condition good.	431	*16	400	73 9	30 6	13,550	4 10 6	16.93 6	100-ton B. L. B. L. Light guns.	34.8 7.87
Andrea Doria	Steel; sister ship to Italia; building	431	.....	400	73 9	30 6	13,550	4 12 6	16.93 6	100-ton B. L. B. L. Light guns.	34.8 7.87
Ruggiero di Lauria	Steel, 1884; similar type to Italia; condition good	.....	*16	328	64 11	29 8	10,045	4 12 6	16.93 6	100-ton B. L. B. L. Light guns.	34.8 7.87
Francesco Morosini	Steel, 1885; similar type to Italia	.....	.....	328	64 11	29 8	10,045	4 12 6	16.93 6	100-ton B. L. B. L. Light guns.	34.8 7.87
Ré Umberto	Steel; type of Italia; building	.....	.....	400	73 9	*28 11	13,251	....	.....	.....	.....
Sicilia	do	.....	.....	400	73 9	*28 11	13,251	....	.....	.....	.....

* Official estimates.

Characteristics of principal

ITALY—Continued.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Armored battle ships—Continued.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*		
Palestro	Composite, 1871; old type battle-ship; belt and two redoubts; ship rig; ram; condition good.	523	12.9	259 2	55 9	25 5	6,161	1	11	25-ton M. L	12.72
								6	10	18-ton M. L	12.13
								6	.....	Light guns.	
Principe Amadeo	Composite, 1872; old type battle-ship; belt and two redoubts; ship rig; ram; condition good.	523	12.4	259 2	55 9	25 5	6,406	1	11	25-ton M. L	12.72
								6	10	18-ton M. L	12.13
								6	.....	Light guns.	
Protected cruisers.											
Giovanni Bausan	Steel, 1884; new type protected cruiser; protective deck, 1½", steel; two masts; military tops; one torpedo tube in bow under water; one each side bow above water; improved Esmeralda type; condition good.	.....	17.5	276 6	42 0	18 6	3,068	2	10	Armstrong B. L.	20
								6	6	....do	7.87
Vesuvio	Steel, 1885; similar type; condition good	.....	*17	283 5	43 4	19	3,530	2	10	25-ton Armstrong B. L.	20
								8	6	B. L.	7.87
Stromboli	....do	.....	*17	283 5	43 4	19 4	3,530	2	10	....do	20
								8	6	....do	7.87
Etna	Steel, 1885; similar type; building	.....	*17	283 5	43 4	19 4	3,530	2	10	....do	20
								8	6	....do	7.87
Tripoli	....do	.....	*17	283 5	43 4	19 4	3.530	2	10	....do	20
								8	6	....do	7.87
Grito	....do	.....	*17	283 5	43 4	19 4	3,530	2	10	....do	20
								8	6	....do	7.87
Unarmored cruisers between 2,000 tons and 4,000 tons.											
Cristoforo Colombo	Wood, 1875; cruiser, 2d class; barkentine rig; condition good	207	16.9	248 6	37 0	16 8	2,362	8	4.72	Armstrong B. L.	.....
Flavio Gioia	Steel, 1881; cruiser, 2d class; bark rig; $\frac{1}{16}$" steel protective deck; condition good.	300	15.5	255 11	41 10	21 6	2,533	8	6	... do	.....
								1	3	....do	.....
								2	3	....do	.....
Amerigo Vespucci	Steel, 1882; cruiser, 2d class; bark rig; $\frac{1}{16}$" steel protective deck; condition good.	300	15	255 11	41 10	21 6	2,533	8	6	....do	.....
								1	3	Do.	
								2	3	Do.	
Savoia	Steel, 1883; fitted as royal yacht; can be armed as the others in war time; condition good.	.....	17	275 7	42	17	2,850	8	6	....do	.....
								1	3	Do.	
								2	3	Do.	
Cruisers between 2,000 tons and 1,000 tons.											
Scilla	Wood, 1874; old type, 3d class cruiser; bark rig; condition good.	136	10.9	178 6	28 3	12 6	1,050	1	6.3	B. L	6.4
								2	4.72	....do	.....
Cariddi	Wood, 1875; old type, 3d class cruiser; bark rig; condition good.	136	10.5	178 6	28 3	12 6	1,050	1	6.3	... do	6.4
								2	4.72	... do	.....
Staffetta	Iron, 1876; new type cruiser, 3d class; barkentine rig; whale-back forecastle; one submerged bow torpedo tube; condition good.	144	15.12	252 9	31 0	15 5	1,505	4	4	....do	.....
Rapido	....do	144	13.5	262 5	30 6	12 8	1,456	5	3	... do	.....
Gun-vessels and gunboats.											
Guardiano	Iron, 1874; gun-boat; coast defense; condition good	48	9.2	100 0	27 3	5 11	265	1	8.5	M. L	9.92
Sentinella	....do	48	8.58	100 0	27 3	5 11	265	1	8.5	....do	9.92

* Official estimates.

Characteristics of principal

ITALY—Continued.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Gun-vessels and gun-boats—Continued.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*		
A. Barberigo	Steel, 1879; gun vessel, two-masted; schooner rig; condition good.	104	15.9	216 6	24 5	10 3	660	2	4.72	B. L	.....
								5	3	....do	.....
M. A. Colonna	.....do	104	15.9	216 6	24 5	10 3	660	2	4.72	... do	.....
								5	3	... do	.....
S. Veneiro	Steel, 1884; gun-vessel, bark rig; condition good	83	*18	168 10	26 2	10 2	649	6	4.72	....do	.....
A. Provana	.....do	83	*18	168 10	26 2	10 2	649	6	4.72	....do	.....
Torpedo vessels.											
Vulcano		41	.....	.....	.....	.....	276	....	.....	.....	.....
Volta		.....	.....	.....	.....	.....	.....	..	.....	.....	.....
Falgore	Sea-going torpedo dispatch vessel	83	.....	.....	.....	.....	317	..	.....	.....	.....
Saetta	.....do	83	.....	.....	.....	.....	317	....	.....	.....	.....
Pietro Micca	Iron, 1876; condition good	41	7	203 0	19 8	11 9	535	....	.....	.....	.....

RUSSIA.

[NOTE.—All data on Russian ships are uncertain, and many of the data obtained have been contradictory.]

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Armored ships.											
Peter Velikij (Peter the Great).	Iron, 1872; battle-ship; belt; breastwork; two turrets; unarmored superstructure between turrets; mastless; protective deck, 3″ thick; condition good.	315	13.2	322 10	63 2	24 9	9,665	4	12	B. L	15.95
								6	5.5	....do	.....
								2	9	Mortars.	
Admiral Nakimoff	Iron and steel; battle-ship and cruiser; full rig; armored barbettes; belt; unprotected broadside; protective deck, 2″ thick; building.	.....	*16	333	61 0	25 9	7,780	4	11	B. L	11.97
								10	6	....do	5.47
Alexander II	Steel; battle-ship and cruiser; full rig; armored barbettes; belt; unprotected broadside; protective deck, 2″ thick; building.	.....	*16	333	61 0	25 9	7.780	4	11	B. L	11.97
								10	6	....do	5.47
Catherine II	Steel and iron; battle-ship; deck 3″ thick; building	500	*16	320	69 0	25 0	10 800	6	12	....do	15.95
								1	6	....do	5.47
								6	6	....do	5.47
Sinope	.....do	.....	*16	314	68 11	25 0	10,800	6	12	....do	15.95
								1	6	....do	5.47
								6	6	....do	5.47
Tcheeme	Steel and iron; sister ship to "Sinope"; building	.....	*16	314	68 11	25 0	10,800	6	12	....do	15.95
								1	6	....do	5.47
								6	6	....do	5.47
Not named	Steel and iron; battle-ship; type of German "Sachren"; building.	.....	.....	352 0	67 0	23 0	8,632	2	9	....do	9.17
								4	8	....do	8.03
								8	6	....do	5.47
General Admiral	Iron and wood, 1873; cruiser; belt; low rectangular redoubt, over which the guns, mounted in barbette, fire; ship rig; condition good.	457	14	281 4	47 11	23 0	4,602	4	8	....do	8.03
								2	6	....do	5.47
								4	4		
								1	6	Mortar.	
Herzog Edinburgh (Duke of Edinburgh).	Iron and wood, 1875; sister ship to General Admiral; condition good.	457	14	281 4	47 11	23 0	4,602	10	6	B. L	5.47
								4	4	Do.	

* Official estimate.

foreign ships of war—Continued.

ITALY—Continued.

Battery.	Torpedo boats.	Weight of fire.			Armor.					Backing.		Remarks.
Position and mounting.		Ahead.	Broadside.	Astern.	Distribution.	Material.	Maximum thickness.	Minimum thickness.	Skin.	Material.	Thickness.	
							In.	*In.*	*In.*		*In.*	
(?)			(?)									
(?)												
(?)			(?)									
(?)												
(?)			(?)									
(?)			(?)									

RUSSIA.

[NOTE.—The weights of projectiles of guns below 6″ caliber are not known, causing some uncertainty in the weights of fire.]

In turrets On superstructure.		1,297	†2,594	1,297	Belt entire length; breastwork 160′ long; two turrets, one forward, one aft.	Iron (sandwich).	14	8	3	Teak	14.10	Built to cope with English "Devastation"; turret armor 17″ iron.
In barbettes In broadside.		1,482	1,962	1,482	Belt and 4 barbettes, one forward, one aft, one each side in waist	Compound	14					Type of "Impérieuse"; barbette armor, 13.8″; compound.
In barbettes In broadside.		1,482	1,962	1,482	Belt and 4 barbettes, one forward, one aft, one each side in waist.	Compound	6					Type of English "Impérieuse" barbette armor, 13.8″; compound.
In barbettes Pivot aft. In broadside.		(?)	(?)	(?)	Belt; 3 barbettes; casemate.	do	15½	12½				Building on the Black Sea; barbette armor, 12″.
In barbettes Pivot aft. In broadside.					do	do	16	15				Do.
In barbettes Pivot aft. In broadside.					do	do	16	15				Do.
In barbette tower, forward. In barbette redoubt, aft.		892	1,276	351								Building at St. Petersburg.
In barbette, two forward fire, two astern, two on each broadside. In barbette, broadside.		351	544+(?)	351	Belt entire length; barbette casemate.	Iron	7	4½				Casemate, 6″.
In barbette, two forward, two aft, five each broadside.		192	480+(?)	192	do	do	7	4½				Do.

Characteristics of principal

RUSSIA—Continued.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Armored ships—Contin'd.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*		
Minin	Iron, 1878; cruiser; belt; four armored barbette half towers, two forward, two aft; unprotected broadside; ship rig; condition good.	520	12.5	285 3	49 0	25 6	5,740	4	8	B. L	8.03
								12	6	....do	5.47
								12	.....	Light guns.	
Vladimir Monomach	Iron and steel, 1882; cruiser; belt; armored barbettes; ship rig; protective deck, 2″ thick; condition good.	550	16	295 0	52 0	25 0	5,796	4	8	B. L	8.03
								12	6	....do	5.47
								4	4		
Dmitri Donskoi	Iron and steel, 1883; cruiser; belt; armored half towers, one each side; unprotected broadside; ship rig; protective deck, 2″ thick; condition good.	612	16	296 7	51 8	25 0	5,796	2	8	....do	8.03
								14	6	....do	5.47
								16	.....	Light guns.	
Moskwa	Steel; similar to "Vladimir Monomach"; brigantine rig; deck, 2″; building.	.....	*16	295 5	52 5	25 0	5,754	4	9	B. L	9.17
								10	6	....do	5.47
								4	3.5		
Admiral Arkass	Steel; sister ship; building	.....	*15	295 5	52 5	25 0	5,754	4	9	....do	.....
								10	6	....do	.....
								4	3.5		
Novgorod	Iron, 1873; circular armor clad; single barbette tower; light draft; coast-defense vessel; dome-shaped deck; flat bottom; condition fair.	110	7.5	(†)	(‖)	13 2	2,490	2	11	... do	11.97
								2	.....	Light guns.	
Vice-Admiral Popoff	Iron, 1875; circular armor clad; single barbette tower; light draft; coast-defense vessel; dome-shaped deck; flat bottom; condition fair.	120	8.3	(‡)	(‡)	14 0	3,550	2	12	B. L	15.96
								4	.....	Light guns.	
Protected cruisers.											
Vitiaz	Steel, 1884; protected cruiser; new type; full rig; protective deck, 1½″, steel; condition good.	400	*15	298 0	45 0	*18 0	2,965	10	6	....do	5.47
Rinda	Steel, 1885; protected cruiser; new type; full rig; protective deck 1½″, steel; condition good.	400	15	298 0	45 0	18 0	2,965	10	6	....do	5.47
Unarmored cruisers between 2,000 tons and 4,000 tons.											
Africa	Iron, 1877; machinery, &c., protected by light armor, built as merchant steamer "Saratoga," at Chester Pa., United States; purchased and altered in 1878; bark rig; can steam 10,000^{m}, at 12^{k}; carries 975 tons coal; condition good.	269	13	278 0	38 0	17 0	2,898	5	6	....do	5.47
								5	4.2	....do	.....
Asia	Iron, 1874; built as merchant steamer "Columbus," at Philadelphia, Pa., United States; purchased and altered in 1878; bark rig; carries 770 tons coal; machinery is protected by light armor; condition good.	258	12.75	262 0	35 0	16 6	2,522	3	6	....do	5.47
								6	4.2	....do	.....
Europa	Iron, 1878; built as merchant steamer "State of California," at Philadelphia; purchased and altered, 1878; bark rig; carries 1,100 tons coal; machinery, &c., protected by light armor; condition good.	289	13.5	300 0	36 11	17 0	3,220	3	6	....do	5.47
								4	4.2	....do	.....
Pamjat Markurija	Iron and steel, 1880; formerly the "Jaroslav," of Moscow Volunteer Fleet; rebuilt by Government and renamed, 1885; bark rig; ram bow; condition good.	.....	*15.5	310 0	41 0	19 8	3,150	2	6	....do	5.47
								4	6	....do	.....
Opyt	Steel, 1880; built in England, nominally as Imperial yacht "Livadia"; intended for service in Black Sea; fitted to carry battery in war time; reported to be dismantled and used as a coal hulk at present; condition bad.	.....	15.8	280 0	153 0	16 0	3,920	....	.....	.....	.....
Unarmored cruisers between 2,000 tons and 1,000 tons.											
Dsigit	Iron; sheathed; 1875; cruiser, old type; bark rig	166	12	207 6	32 10	15 8	1,480	3	6	B. L	.....
								4	4	Do.	
Krejser	.....do	166	13	207 4	33 10	16 6	1,599	3	6	....do	.....
								4	4	Do.	

* Official estimate. † 101′ in diameter. ‡ 121′ in diameter.

foreign ships of war—Continued.

RUSSIA—Continued.

Battery.	Torpedo boats.	Weight of fire.			Armor.					Backing.		Remarks.
Position and mounting.		Ahead.	Broadside.	Astern.	Distribution.	Material.	Maximum thickness.	Minimum thickness.	Skin.	Material.	Thickness.	
							In.	*In.*	*In.*		*In.*	
In barbette half towers. In broadside.		351	927+	351	Belt entire length; 4 half towers, one on each side forward, one each side aft.	Iron	7					Barbettes, 8″; iron.
In barbette towers. In broadside.		573	1,102+	573	Complete water-line belt 7′3″ wide; belt 4′ wide in wake of broadside battery; 4 barbette ½ towers.	Compound	9	6				Barbettes, 12″; compound.
In barbette half towers, one each side. In broadside.		351	847+	351	Belt complete; 2 barbette half towers; one each side.	do	7			Teak	24	Barbettes, 6″; compound.
In barbette towers. In broadside.		541	1,291+	270	Belt complete; 4 barbette towers; one aft, one in waist, one each side for'd, abreast.	do	8.3	5.8		do		Barbettes, 12″; compound.
In barbette towers. In broadside.		541	1,291+	270	do	do	8.3	5.8				Do.
In barbette tower		988	988	988	Complete armor; one barbette in center.	Iron	11	9		do	7	Barbettes, 30′ diameter, 11″ thick
In barbette tower on deck.		1,297	1,297	1,297	do	Iron (sandwich).	18	16		do	7	Barbettes, 34′ diameter, 18″ thick.
Four on sponsons, two forward, two aft, six in broadside.		192	481	192								
Do		192	481	192								
Pivots. Broadside (?).			(?)									
Pivots. Broadside.			408									
Pivots. Broadside.			338									
Pivots. Broadside.			384									
Pivots. Broadside.			328									
do			328									

Characteristics of principal

RUSSIA—Continued.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Unarmored cruisers between 2,000 tons and 1,000 tons—Continued.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*		
Zabijaka	Iron, 1878; cruiser, built in Philadelphia; barkentine rig; can steam 6,000^{m} at 10^{k}; condition good.	151	14.5	200 0	30 0	14 4	1,220	2	6	B. L	.....
								4	4	....do	.....
Razbojnik	Iron; sheathed; 1878; type of Dzigit; two torpedo ports above water; condition good.	.....	13	207 4	32 10	14 11	1,350	3	6	....do	.....
								4	4	...do	.....
Najezdnik	Composite, 1878; type of Dzigit; two torpedo ports above water; condition good.	180	13	207 4	32 10	14 6	1,355	3	6	....do	.....
								4	4	....do	.....
Strelok	Iron, sheathed; 1879; type of Dzigit; two torpedo ports above water; condition good.	188	13	207 4	32 10	14 3	1,364	3	6	... do	.....
								4	4	.. do	.....
Plastun	Composite, 1879; type of Dzigit; two torpedo ports above water; condition good.	.....	12.3	207 4	32 10	14 0	1,275	3	6	.. do	.....
								4	4	Do.	
Vjestnik	Composite, 1880; type of Dzigit; two torpedo ports above water; condition good.	....	12	207 4	32 10	14 0	1,275	3	6	..do	.....
								4	4	Do.	
Opritcnik	Composite, 1880; new type cruiser; bark rig; condition good.	182	13	207 6	32 11	16 3	1,511	4	6	....do	.....
Gun-vessels and gunboats.								2	4	Do.	
Jermak	Iron, 1870; schooner rig; gun-vessel on Siberian coast; condition good.	.....	.....	154 0	25 11	11 0	706	2	4	...do	.....
Tungus	.....do	.....	.....	154 0	25 11	11 0	706	2	4	.. do	.....
Ingul	Iron, 1872; schooner rig; gun-vessel in Black Sea; condition good.	.....	.....	180 5	26 3	12 5	749	2	.....	.....	.....
Ersch	Composite, 1874; gunboat of British Staunch type; condition good.	.....	9	98 5	28 6	6 7	290	1	11	... do	11.97
Jorsch	.....do	.....	9	98 5	28 0	6 8	305	1	11	....do	11.97
Wichr	Composite, 1879; gunboat, with pivot gun in bow; condition good.	.....	9.5	110 0	38 0	7 8	377	1	11	.. do	11.97
								2	4	....do	.....
Burun	Composite, 1879; gunboat, Staunch type; condition good.	.....	9	118 0	29 0	7 2	402	1	11	....do	11.97
								2	4	.. do	.....
Tuchu	.....do	.....	9	118 0	29 0	7 2	402	1	11	....do	11.97
								2	4	...do	.....
Kartech	Composite, 1879; gunboat, Staunch type; condition good.	.....	9	118 0	29 0	7 2	402	1	11	...do	11.97
								2	4	Do.	
Doschd	Composite, 1879; gunboat, Staunch type; condition good.	.....	9.25	110 0	34 4	7 1	383	1	11	B. L	11.97
								2	4	....do	.....
Bruja	Composite, 1880; gunboat, Staunch type; condition good.	.....	9	118 0	29 0	7 2	383	1	11	....do	11.97
								2	4	Do.	
Groza	.....do	.....	9	118 0	29 0	7 2	383	1	11	... do	11.97
								2	4	Do.	
Grad	Composite, 1881; gunboat, Staunch type; condition good.	.....	9	118 0	29 0	7 2	383	1	11	....do	11.97
								2	4	Do.	
Snjed	.....do	.....	9	118 0	29 0	7 2	383	1	11	...do	11.97
								2	4	Do.	
Oltjow	Composite, 1882; gunboat, Staunch type; condition good.	.....	9	118 0	29 0	7 2	383	1	11	.. do	11.97
								2	4	Do.	
Bobr	Composite, 1883; built in Finland for Siberia; brig rig; condition good.	.....	12	187 0	35 0	9 6	950	1	9	....do	9.17
								1	6	... do	5.47
								6	4	Do.	
Sivoutch	Composite, 1883; built in Sweden for Siberia; brig rig; condition good.	.....	12	187 0	35 0	9 6	950	1	9	....do	9.17
								1	6	....do	5.47
								6	4	Do.	

Characteristics of principal

GERMANY.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught att.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Armored vessels.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*		
Preussen	Iron, 1873; battle-ship, British "Monarch" type; belt, turrets, and breastwork; ship rig; condition good.	537	14	307 5	53 6	24 7	6,770	4	10.25	Krupp B. L.	14.7
								2	6.7	do	7.6
Friedrich der Grosse	Iron, 1874; sister ship to Preussen	537	14	307 5	53 6	24 7	6,770	4	10.25	do	14.7
								2	6.7	do	7.6
Kaiser	Iron, 1874; battle-ship; broadside casemate; belt; ship rig; condition good.	638	14.6	279 11	62 0	26 0	7,676	8	10.25	do	14.7
								1	8.25	do	9.57
Deutschland	do	638	14.6	279 11	62 0	26 0	7,676	8	10.25	do	14.7
								1	8.25	do	9.57
Sachsen	Iron, 1877; battle-ship; guns in barbette; forward gun in pear-shaped tower; after guns in rectangular overhanging redoubt, 2″ iron hurricane deck over them; main protective deck 3″ iron; belt in wake of machinery and magazine only; one mast; military top; derricks for handling boats; condition good.	354	14	298 7	60 0	19 8	7,400	4	10.25	do	14.7
								1	11.75	do	19.8
Bayern	Iron, 1878; sister ship to Sachsen	354	14	298 7	60 0	19 8	7,400	4	10.25	do	14.7
								1	11.75	do	19.8
Wurtemburg	do	354	14	298 7	60 0	19 8	7,400	4	10.25	do	14.7
								1	11.75	do	19.8
Baden	Iron, 1880; sister ship to Sachsen	354	14	298 7	60 0	19 8	7,400	4	10.25	do	14.7
								1	11.75	do	19.8
Oldenburg	Steel, 1884; battle-ship of smaller type; casemate battery; one mast; military top; ram; condition good.	.....	14	249 0	59 0	19 6	5,200	6	9.45	do	18.15
								2	9.45	do	18.15
Hansa	Wood, 1872; cruiser; belt; casemate protecting battery; ship rig; condition fair.	397	12	224 6	46 3	21 7	3,610	4	8.25	do	9.57
								4	8.25	do	9.57
Armored gunboats.											
Viper	Iron, 1876; armored gunboat for coast defense; one signal mast; heavy ram bow; low speed; condition good.	76	9	142 9	35 0	10 2	1,109	1	12	do	19.8
Wespe	do	76	9	142 9	35 0	10 2	1,109	1	12	do	19.8
Biene	do	76	9	142 9	35 0	10 2	1,109	1	12	do	19.8
Scorpion	Iron, 1877; sister ship to Viper	76	9	142 9	35 0	10 2	1,109	1	12	do	19.8
Mücke	do	76	9	142 9	35 0	10 2	1,109	1	12	do	19.8
Basilisk	Iron, 1878; sister ship to Viper	76	9	142 9	35 0	10 2	1,109	1	12	do	19.8
Camëleon	do	76	9	142 9	35 0	10 2	1,109	1	12	do	19.8
Crokodile	Iron, 1879; sister ship to Viper	76	9	142 9	35 0	10 2	1,109	1	12	do	19.8
Natter	Iron, 1880; sister ship to Viper	76	9	142 9	35 0	10 2	1,109	1	12	do	19.8
Salamander	do	76	9	142 9	35 0	10 2	1,109	1	12	do	19.8
Hummel	Iron, 1881; sister ship to Viper	76	9	142 9	35 0	10 2	1,109	1	12	do	19.8
Brummer	Steel, 1884; similar type, but high speed; armored deck 2½″ compound; condition good.	76	*15	203 5	27 10	10 6	875	1	12	do	19.8
Bremse	Steel, 1885; sister ship to Brummer	76	*15	203 5	27 10	10 6	875	1	12	do	19.8
Unarmored cruisers between 2,000 and 4,000 tons.											
Freya	Wood, 1874; old type cruiser; ship rig; corvette; condition good.	248	15	259	36 1	19	2,017	8	5.91	do	5.67

* Official estimate.

foreign ships of war—Continued.

GERMANY.

Battery.	Torpedo boats.	Weight of fire.			Armor.					Backing.		Remarks.
Position and mounting.		Ahead.	Broadside.	Astern.	Distribution.	Material.	Maximum thickness.	Minimum thickness.	Skin.	Material.	Thickness.	
							In.	*In.*	*In.*		*In.*	
In turrets. Pivot; one bow, one stern fire.	.....	123	1,645	123	Belt complete; two turrets; breastwork, 90′ 6″x53′ 6″.	Iron	10.5	5.4	1¼	Teak .	9½–10½	Built at Stettin, Germany. Turrets on fore and aft line, 8¼″ to 10½″ thick.
In turrets. Pivot; one bow, one stern fire.	.....	123	1,645	123	... do	....do	10.5	5.4	1¼	..do ...	9½–10½	Turrets on fore and aft line, 8¼″ to 10½″. Built at Kiel.
In casemate; two bow fire. On main deck; stern fire.	.....	823	1,645	216	Belt complete; rectangular casemate; protection for stern gun.	....do	11.25	6¼	1¼	..do ...	10	Built at Poplar, England.
In casemate; two bow fire. On main deck; stern fire.	.....	823	1,645	216	....do	....do	11.25	6¼	1¼	..do ...	10	Do.
In barbette redoubt, aft. In barbette tower, forward.	.....	1,538	1,538	823	Belt, 135′ 4″ long; barbette tower and barbette redoubt.	Iron (sandwich).	17.25	15¼	1¼	..do ...	17½–15¾	Built at Stettin.
Same as Sachsen.....	.....	1,538	1,538	823	....do	....do	17.25	15¼	1¼	..do ...	17½–15¾	Built at Kiel.
.....do	.....	1,538	1,538	823	....do	....do	17.25	15¼	1¼	..do ...	17½–15¾	Built at Stettin.
.....do	.....	1,538	1,538	823	....do	....do	17.25	15¼	1¼	..do ...	11½–15¾	Built at Kiel.
On main deck; casemate. On upper deck; one each side, in barbette.	.....	1,408	1,408	1,408	.....	Compound	12.87	.....	.....	.....	.....	Built at Stettin.
In upper casemate; two bow, two stern fire. In lower casemate; broadside.	.....	432	864	432	Belt complete; casemate; double-decked.	Iron	6.25	4½	.....	Teak .	12⅝ ..	Built at Dantzig.
In barbette tower forward; trained by helm.	.....	715	.....	.....	Belt complete; one barbette tower forward.	... do	8	.....	.....	.....	.....	Barbette armor 8″. Built at Bremen.
.....do	.....	715	.....	.....	....do	....do	8	.....	.....	.....	.....	Do.
.....do	.....	715	.....	.....	....do	....do	8	.....	.....	.....	.....	Do.
.....do	.....	715	.....	.....	....do	....do	8	.....	.....	.....	.....	
.....do	.....	715	.....	.....	....do	....do	8	.....	.....	.....	.....	
.....do	.....	715	.....	.....	....do	... do	8	.....	.....	.....	.....	
.....do	.....	715	.....	.....	....do	....do	8	.....	.....	.....	.....	
.....do	.....	715	.....	.....	....do	....do	8	.....	.....	.....	.....	
.....do	.....	715	.....	.....	... do	.. do	8	.....	.....	.....	.....	
.....do	.....	715	.....	.....	... do	... do	8	.....	.....	.....	.....	
.....do	.....	715	.....	.....	....do	....do	8	.....	.....	.....	.....	
.....do	.....	715	.....	.....	No belt; armored barbette tower forward.	Compound	8	.....	.....	.....	.....	Built at Bremen.
.....do	.....	715	.....	.....	....do	.....	.....	.....	.....	.....	.....	Do.
pivots, 4 broadside....	.....	.....	468	.....	.....	.....	.....	.....	.....	.....	.....	

Characteristics of principal

GERMANY—Continued.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Unarmored cruisers between 2,000 and 4,000 tons—Continued.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*		
Leipzig	Iron, sheathed; 1875; gun-deck corvette; ship rig; condition good.	432	16	282 2	45 11	21 7	3,925	1	6.7	Krupp B. L	7.6
								10	6.7	do	6.1
Prinz Adalbert	Iron, sheathed; 1876; sister ship to Leipzig	432	16	282 2	45 11	21 7	3,925	1	6.7	do	6.1
								10	6.7	do	6.1
Bismarck	Iron, sheathed; 1877; gun-deck corvette of smaller type; condition good.	404	14	244 4	43 3	19 8	2,856	4	5.91	do	5.67
								12	5.91	do	5.67
Blücher	do	404	14	244 4	43 3	19 8	2,856	4	5.91	do	5.67
								12	5.91	do	5.67
Stosch	do	404	14	244 4	43 3	19 8	2,856	4	5.91	do	5.67
								12	5.91	do	5.67
Moltke	do	404	14 1	244 4	43 3	19 8	2,856	4	5.91	do	5.67
								12	5.91	do	5.67
Gneisnau	Iron, sheathed; 1879; sister ship to Bismarck	404	14 8	244 4	43 3	19 8	2,856	4	5.91	do	5.67
								12	5.91	do	5.67
Stein	do	404	14	244 4	43 3	19 8	2,856	4	5.91	do	5.67
								12	5.91	do	5.67
Carola	Iron and steel, sheathed; 1880; spar-deck corvette; bark rig; condition good.	267	14	226 4	41	18 4	2,169	8	5.91	do	6.73
								2	3.42	do	.....
Olga	do	267	14	226 4	41	18 4	2,169	8	5.91	do	6.73
								2	3.42		
Marie	Iron and steel, sheathed; 1881; sister vessel to Carola	267	15	226 4	41	18 4	2,169	8	5.91	do	6.73
								2	3.42		
Sophie	do	267	14	226 4	41	18 4	2,169	8	5.91	do	6.73
								2	3.42		
Alexandrina	Steel composite, 1885; improved Carola type; condition good.	267	14	234 6	41 4	16 5	2,370	12	5.91	do	6.73
								2	3.42		
Not named. To replace Nymphe.	Improved Carola type; building	267	14	234 6	41 4	16 5	2,370	12	5.91	do	.....
								2	3.42		
Not named. To replace Medusa.	do	267	14	234 6	41 4	16 5	2,370	12	5.91	do	.....
								2	3.42		
Not named. To replace Victoria.	Steel; improved Bismarck type; building	427	14	.....	.....	.....	3,360	18	5.91	do	.....
Not named. To replace Prinz Adalbert. (Iron clad.)	Steel; building	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Cruisers between 2,000 and 1,000 tons.											
Ariadne	Wood, 1871; gun-deck corvette; bark rig; condition good.	238	13	204	35	17 1	1,719	6	5.91	Krupp B. L	5.67
								2	4.72	do	4.72
Luise	Wood, 1872; sister ship to Ariadne	238	14	204	35	17 1	1,719	6	5.91	do	5.67
								2	4.72	do	4.72
Blitz	Steel, 1882; dispatch cruiser; schooner rig; ram bow; condition good.	127	16	245 1	32 6	13 6	1,382	1	4.72	do	4.72
								4	3.42	do	.....
Pfeil	do	127	16	245 1	32 6	13 6	1,382	1	4.72	do	4.72
								4	3.42		
Gun-vessels and cruising gunboats.											
Albatross	Wood, 1871; gun-vessel; bark rig; condition good	115	12	168	26 10	10 10	716	2	5.91	do	5.67
								2	4.72	do	4.72
Nautilus	do	115	10 6	168	26 10	10 10	716	2	5.91	do	5.67
								2	4.72	do	4.72

foreign ships of war—Continued.

GERMANY—Continued.

Battery.		Weight of fire.			Armor.					Backing.		Remarks.
Position and mounting.	Torpedo boats.	Ahead.	Broadside.	Astern.	Distribution.	Materials.	Maximum thickness.	Minimum thickness.	Skin.	Material.	Thickness.	
							In.	*In.*	*In.*		*In.*	
Pivot, under top-gallant forecastle.		78	390									
Broadside, gun-deck.												
do		78	390									
On spar-deck; 2 bow, 2 stern fire.		156	628	156								
Broadside, gun-deck.												
do		156	628	156								Is torpedo training ship. Has six torpedoes under-water tubes, 1 bow, 1 stern, 2 each broadside.
do		156	628	156								NOTE: Weights of heaviest projectiles:
do		156	628	156								*Lbs.*
do		156	628	156								15cm (5.91") long 78.1
do		156	628	156								15cm (5.91") short 78.1
												17cm (6.7") long 122.7
												17cm (6.7") short 110.0
												12cm (4.72") 38.5
(?)			(?)									
On forecastle, bow fire.												
Same as Carola			(?)									
do			(?)									
do			(?)									
(?)			(?)									
(?)			(?)									
(?)			(?)									
(?)			(?)									
Pivot on forecastle; bow fire.												
Broadside.												
Same as Blitz												
Pivots												
(?)												
Same as Albatross												

Characteristics of principal

GERMANY—Continued.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions: Length.	Dimensions: Breadth.	Dimensions: Draught aft.	Dimensions: Displacement.	Battery: Number.	Battery: Caliber.	Battery: Type.	Battery: Power (inches of wrought iron at muzzle).
Gun-vessels and cruising gunboats—Continued.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*		
Cyclop	Iron, 1874; cruising gunboat; brigantine rig; condition good.	67	8	138 5	22 11	9 10	412	2	4.72	Krupp B. L.	*.72
								2	3.15	do	
Wolf	Iron, 1878; cruising gunboat; topsail schooner rig; condition good.	87	10	139 2	25 1	9 10	489	2	4.72	do	4.72
								2	3.15		
Hyäne	do	87	11	139 2	25 1	9 10	489	2	4.72	do	
								2	3.15		
Iltis	do	87	11	139 2	25 1	9 10	489	2	4.72	do	
								2	3.15		
Zieten	Iron, 1876; cruising torpedo vessel; 2 tubes (one forward, one aft), 6′ below water-line; condition good.	111	16	196 10	27 10	11 7	975	4	4.72	do	4.72
Habicht	Steel and iron, 1879; gun-vessel; condition good	127	10 5	174	29 6	11 5	848	1	5.91	do	6.73
								4	4.72	do	4.72
Möwe	do	127	10 5	174	29 6	11 5	848	1	5.91	do	6.73
								4	4.72	do	4.72
Adler	Steel, 1883; gun-vessel; condition good		10 3				883	1	5.91	do	6.73
								4	4.72	do	4.72

SPAIN.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions: Length.	Dimensions: Breadth.	Dimensions: Draught aft.	Dimensions: Displacement.	Battery: Number.	Battery: Caliber.	Battery: Type.	Battery: Power (inches of wrought iron at muzzle).
Armored vessels.											
(Not named)	Steel; battle-ship; type of French "Amiral Duperré;" armored barbette; belt; unprotected broadside; protective deck; building.		*15.5	344 6	66 2	24 8	9,902	2	12.6	48-ton Hontoria B. L.	19.84
								2	11	38-ton Hontoria B. L.	15.95
								13	(?)		
Sagunto	Wood, 1869; old-type broadside battle-ship; ship rig; condition good.	554	8	279 2	54 1	25 11	7,352	8	9	12-ton Armstrong	9.84
								3	7	Palliser	7.44
Numancia, Vitoria, Zaragoza, Mendes Nunes	Old type broadside armored ships; low speed; 5″ maximum armor; 8″, 9″, 10″, old type, Armstrong M. L. R.; built 1860–1870. Numancia and Vitoria, iron; Zaragoza and Mendes Nunez, wood; condition of all poor.										
Duque de Tetuan	Wood, 1874; floating battery; fair	85	8	141 0	31 1	6 11	703	1	6.3	Palliser.	
								4	4.7	B. L	4.72
Puigcerda	Iron, 1874; river monitor; condition good	70	8	127 11	29 6	6 7	553	1	6.3	Palliser.	
								2	4.7	B. L	4.72
Unarmored vessels.											
Aragon	1879, wood and iron; new type fast unarmored cruiser; bow and stern fire from guns in sponsons; condition good.	360	17	242 8	42 8	24 0	3,342	4	6.3	No. 1 Hontoria	
								4	6.3	No. 2 Hontoria	
								4	3.4	Krupp	
Castilla	1881; sister ship to Aragon	360	*15	242 8	42 8	24 0	3,342	4	6.3	No. 1 Hontoria	
								4	6.3	No. 2 Hontoria.	
								4	3.4	Krupp.	
Navarra	do	360	*15	242 8	42 8	24 0	3,342	4	6.3	No. 1 Hontoria	
								4	6.3	No. 2 Hontoria.	
								4	3.4	Krupp.	
Reina Cristina	Wood; new type unarmored cruiser; smaller class; building.		*15.5	264 0	41 0	21 0	3,090	8	6.3	Hontoria	
								4	3.54	B. L.	
Reina Mercedes	do		*15.5	264 0	41 0	21 0	3,090	8	6.3	Hontoria	
								4	3.54	B. L.	
Alphonso XII	do		*15.5	264 0	41 0	21 0	3,090	8	6.3	Hontoria	
								4	3.54	B. L.	

* Official estimate.

foreign ships of war—Continued.

GERMANY—Continued.

Battery.	Torpedo boats.	Weight of fire.			Armor.					Backing.		Remarks.
Position and mounting.		Ahead.	Broadside.	Astern.	Distribution.	Material.	Maximum thickness.	Minimum thickness.	Skin.	Material.	Thickness.	
							In.	*In.*	*In.*		*In.*	
Pivots												
Broadside.												
Same as Cyclop												
do												
do												
(?)												
Pivots		71	149									
Broadside; 2 have bow fire.												
Same as Habicht		71	149									
do		71	149									
SPAIN.												
In barbettes; one aft, one in waist.		1.518	(?)	759	Belt complete; barbette towers; ammunition tubes.	Steel	17.7	11.8				Building in France ("Forges et Chantier"); to be completed 1887.
In barbettes; one each side, forward.												
On main deck, broadside												
In broadside, casemate main deck.					Belt complete; casemate in wake of battery, main deck; short central casemate upper deck.	Iron	5.9	4		Wood.	22½	Built in Spain; completed 1876.
In casemate, spar-deck.												
						do	3.93			Teak	9	
In one turret, 3 ports		141	141		Monitor type; one turret.	do	3.93	3		do	7.87	
In sponsons, two forward, two aft.		167+	334+	167								Built at Cartagena.
In broadside.												
On top-gallant forecastle.												
Same as Aragon		167+	334+	167+								Built at Cadiz.
do		167+	334+	167+								Built at Ferrol.
		(?)	(?)	(?)								
		(?)	(?)	(?)								
		(?)	(?)	(?)								

Characteristics of principal

SPAIN—Continued.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Unarmored vessels—Con'd.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*		
Velasco	Iron, 1881; 3d class unarmored cruiser; condition good.	173	.....	193 2	29 0	11 4	1,152	3	6	B. L	.....
Conde del Venadito	Third class unarmored cruiser; building; to be launched 1885.	173	.....	193 2	29 0	11 4	1,152	5	4.72	Hontoria B. L	4.72
Cristobal Colon	do	173	.....	193 2	29 0	11 4	1,152	5	4.72	do	4.72
Don Juan de Austria	do	173	.....	193 2	29 0	11 4	1,152	5	4.72	do	4.72
Infante Isabel	do	173	.....	193 2	29 0	11 4	1,152	5	4.72	do	4.72
Isabel II	do	173	.....	193 2	29 0	11 4	1,152	5	4.72	do	4.72
Ulloa	do	173	.....	193 2	29 0	11 4	1,152	5	4.72	do	4.72
Jorge Juan	Iron, 1876; 3d class unarmored cruiser; condition good.	146	13.45	203 5	29 7	15 0	935	1	6.3	do	.....
								2	6.3	do	.....
Sanchez Barcaiztegui	do	146	13.23	203 5	29 7	15 0	935	1	6.3	do	.....
								2	6.3		
Concha	Iron, 1883; first class gunboat; condition good	.....	.....	160 0	25 0	.....	524	3	(†)	.....	.....
Elcano	Iron, 1883; first class gunboat; building	.....	.....	160 0	25 0	.....	524	3	.....	.....	.....
General Lezo	do	.....	.....	160 0	25 0	.....	524	3	.....	.....	.....
Magellanes	do	.....	.....	160 0	25 0	.....	524	3	.....	.....	.....

AUSTRIA.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Armored vessels.											
Kaiser	Wood and iron, 1871; old type casemate battle-ship; converted from wooden line of battle-ship; ship rig; condition poor.	.....	12.7	254 1	58 2	26 3	5,810	10	9	Armstrong M.L.	10.31
								6	3.54	Uchatius.	
Custoza	Iron, 1872; old type battle-ship; double-decked casemate; sides cut away forward and aft to allow of nearly bow and stern fire; ship rig; condition good.	.....	14	302 2	58 0	26 9	7,060	8†	10¼†	Krupp B. L	11.89
								6	3.54	Uchatius.	
Erzherzog Albrecht	Iron, 1872; similar type; sides cut away for four guns, bow fire; two guns nearly stern fire; condition good.	.....	13.5	288 2	56 2	25 3	5,940	8	9½	do	10.35
								6	3.54		
Tegetthoff	Iron and steel, 1878; new type casement battle-ship; ship rig; protective deck 3″; condition good.	.....	14.3	286 10	62 4	26 7	7,390	6	11	do	16.89
								6	3.54		
Kronprinz Erzherzog Rudolf.	Steel; turret battle-ship; building	.....	.....	295 2	62 4	25 3	6,900	3	12	Krupp	19.8
								6	3.54	Uchatius.	
Ferdinand Max	do	.....	.....	278 8	55 7	21 6	5,100	2	12	Krupp	19.8
								4	5.9	Do.	
Don Juan de Austria	Iron and steel, 1875; cruiser, casemate iron-clad of old type; ship rig; condition good.	.....	13.6	240 3	50 0	20 9	3,550	8	8.3	do	8.5
								4	3.54	Uchatius.	
Kaiser Max	do	.....	13.4	240 3	50 0	20 9	3,550	8	8.3	do	8.5
								4	3.54		
Prinz Eugene	Iron, 1877; sister ship to Don Juan de Austria	.....	13.5	240 3	50 0	20 9	3,550	8	8.3	do	8.5
								4	3.54		
Maros	Iron and steel, 1871; river monitor for Danube; freeboard 1′ 7″ at ends, 3′ 2″ in waist; condition good.	.....	8.5	165 10	27 7	3 7	310	2	6	.....	6.61
Leitha	do	.....	8.5	165 10	27 7	3 7	310	2	6	.....	6.61
Hapsburg	Wood, 1865; to be rebuilt as new type battle-ship	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Salamander	Wood, 1861; to be rebuilt as single turret battle-ship.	.....	.....	.....	.....	.....	.....	2	12	Krupp	19.8
Unarmored cruisers between 2,000 tons and 4,000 tons.											
Radetzky	Composite, 1872; second class frigate, ship rig; condition good.	.....	14.2	253 0	47 0	23 7	3,430	1	5.91	Krupp B. L	6.42
								14	5.91	do	6.42
Laudon	Composite, 1873; second class frigate, ship rig; condition good.	.....	13.6	253 0	47 0	23 7	3,430	1	5.91	do	6.42
								14	5.91	do	6.42

foreign ships of war—Continued.

SPAIN—Continued.

Battery.		Weight of fire.			Armor.					Backing.		
Position and mounting.	Torpedo boats.	Ahead.	Broadside.	Astern.	Distribution.	Material.	Maximum thickness.	Minimum thickness.	Skin.	Material.	Thickness.	Remarks.
							In.	*In.*	*In.*		*In.*	
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Built at London.
.....	.....	(?)	(?)	(?)	.....	.....	.....	.....	.....	.....	.....	
.....	.....	(?)	(?)	(?)	.....	.....	.....	.....	.....	.....	.....	
.....	.....	(?)	(?)	(?)	.....	.....	.....	.....	.....	.....	.....	
.....	.....	(?)	(?)	(?)	.....	.....	.....	.....	.....	.....	.....	
.....	.....	(?)	(?)	(?)	.....	.....	.....	.....	.....	.....	.....	
.....	.....	(?)	(?)	(?)	.....	.....	.....	.....	.....	.....	.....	
Pivot on top-gallant forecastle.	.....	250.5	167	167	.....	.....	.....	.....	.....	.....	.....	Built by "Forges et Chantier".
In sponsons abaft foremast.												
Same as Jorge Juan ...	.....	250.5	167	167	.....	.....	.....	.....	.....	.....	.....	Do.
.....	.....	(?)	(?)	(?)	.....	.....	.....	.....	.....	.....	.....	
.....	.....	(?)	(?)	(?)	.....	.....	.....	.....	.....	.....	.....	
.....	.....	(?)	(?)	(?)	.....	.....	.....	.....	.....	.....	.....	
.....	.....	(?)	(?)	(?)	.....	.....	.....	.....	.....	.....	.....	

AUSTRIA.

In casemate, eight on main, two on upper deck.	.....	255	1,275+	.....	Belt complete; casemate protecting battery; one 3 port turret each side upper deck.	Iron	6¼	5½	.....	.....	31	Built 1858; rebuilt 1871; converted to ironclad 1872.
In casemate, four on each deck.	.....	.....	1,580+	.....	Belt complete; double-decked casemate; bulkheads.	Iron	9	6	1¼	.....	8¼	
..... do	.....	1,166	1,166	583	... do	....do	8	7	.....	.....	9½	
In casemate, two bow, two stern fire.	.....	1,113+	1,169+	1,113	Belt to 32′ 10″ of bow; bulkhead; casemate divided by bulkhead.	.....	14½	12	1½	.....	10	Two guns in forward compartment of casemate have bow and beam fire; four guns in after compartment.
(?)	.....	.....	(?)	.....	(?)	.....	12	.....	.....	.....	.....	Weight of 12″ shell, 715 pounds.
(?)	.....	.....	(?)	.....	(?)	.....	(?)	.....	.....	.....	.....	
In casemate, no bow or stern fire.	.....	.....	824+	.....	Belt complete; casemate; bulkheads.	Iron	8	.....	1¼	.....	9½	Built 1862 of wood; rebuilt of iron and steel, and armored, 1875. Bunkers in hold and lower deck in wake of boilers and engines.
..... do	.....	.....	824+	.....	....do	....do	8	.....	1¼	.....	9½	Do.
..... do	.....	.....	824+	.....	....do	....do	8	.....	1¼	.....	.....	Do.
In turret	.....	170	170	.....	Belt; one turret; monitor type.	....do	2½	.....	1.7	.....	7½	Turret revolves by hand.
..... do	.....	170	170	.....	....do	....do	2½	.....	1.7	.....	7½	Do.
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
In turret	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
Pivot, spar-deck	.....	.....	594	.....	.....	.....	.....	.....	.....	.....	.....	
Broadside, gun-deck.												
..... do	.....	.....	594	.....	.....	.....	.....	.....	.....	.....	.....	
Do.												

Characteristics of principal

AUSTRIA—Continued.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Unarmored cruisers between 2,000 tons and 4,000 tons—Continued.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*		
Donau	Composite, 1874; gun-deck corvette, ship rig; condition good.	.....	12	233 0	42 6	20 0	2,510	1	5.91	Krupp B. L	6.42
								10	5.91	do	6.42
Saida	Composite, 1878; gun-deck corvette, ship rig; condition good.	.....	12	233 0	42 6	20 0	2,440	1	5.91	do	6.42
								10	5.91	do	6.42
Cruisers between 2,000 tons and 1,000 tons.											
Fasana	Composite, 1870; spar-deck corvette, ship rig; condition good.	.....	12	223 0	39 4	20 4	1,970	4	5.91	do	6.42
Zrinyi	Composite, 1871; spar-deck corvette, bark rig: condition good.	.....	11.32	193 6	32 10	17 8	1,340	4	5.91	Wahrendof B. L.	(?)
Aurora	Composite, 1873; sister ship to Zrinyi	.....	11.18	193 6	32 10	17 8	1,340	4	5.91	do	(?)
Frundsberg	do	.....	11.18	193 6	32 10	17 8	1,340	4	5.91	do	(?)
Gun-vessels and gunboats.											
Albatross	Composite, 1873; cruising gunboat, barkentine rig; condition good.	.....	10	151 0	26 3	11 10	570	2	5.91	do	(?)
Nautilus	do	.....	9.68	151 0	26 3	11 10	570	2	5.91	do	(?)
Gun and torpedo vessels.											
Zara	Steel, 1879; gun and torpedo vessel, schooner rig; condition good.	.....	14	180 0	26 3	13 9	840	4	3.54	Uchatius B. L.	.....
Spalato	do	.....	14	180 0	26 3	13 9	840	4	3.54	do	.....
Sebenico	Steel, 1882; gun and torpedo vessel, schooner rig; condition good.	.....	14	187 0	26 3	12 0	880	2	5.91	Krupp B. L	6.42
Lussin	Steel, 1883; gun and torpedo vessel, schooner rig; condition good.	.....	.....	200 0	26 3	12 0	913	2	5.91	do	6.42
Panther	Steel, 1885; gun and torpedo vessel of "Scout" type; six torpedo tubes; one in bow; one in stern; two each broadside; protective deck over boilers; condition good.	.....	.....	.....	.....	.....	1,500	2	4.72	B. L	4.41
(* *)	Sister vessel building.										

HOLLAND.

Armored vessels.											
Koning der Nederlanden	Iron, 1874; turreted cruiser and battle-ship; ship rig; condition good.	.....	11.9	268 0	54 0	19 0	5,285	4	11	Armstrong M. L.	13.74
								4	4.72	Krupp B. L	4.72
Draak	Iron, 1877; ram monitor; belt; one turret; mastless; condition good.	.....	9	202 5	49 0	11 0	2,156	2	11	Krupp	15.95
Haai	Iron, 1871; similar type to Draak	.....	7	186 0	44 0	9 10	1,525	2	9	Armstrong M.L	9.84
Weep	do	.....	7	186 0	44 0	9 10	1,525	2	9	do	9.84
Luipaard	Iron, 1876; sister vessel	.....	7	186 0	44 0	9 10	1,525	1	11	Krupp B. L	13.75
Panter	Iron, 1870; sister vessel	.....	7	186 0	44 0	9 10	1,525	2	9	Armstrong M.L.	9.84
Hyaena	do	.....	7	186 0	44 0	9 10	1,525	2	9	do	9.84
Matador	Iron, 1878; similar type to Draak	.....	7	200 0	47 5	9 10	1,650	2	11	Krupp	13.75
Isala	Iron, 1876; turreted gunboat; condition good	.....	8	151 0	25 0	4 3	367	2	4.72	do	4.72
Rhenus	Iron, 1877; turreted gunboat; condition good	.....	8	151 0	25 0	4 3	367	2	4.72	do	4.72
Mosa	Iron, 1878; turreted gunboat; condition good	.....	8	151 0	25 0	4 3	367	2	4.72	do	4.72
Merva	Iron, 1879; turreted gunboat; condition good	.....	8	151 0	25 0	4 3	367	2	4.72	do	4.72
Unarmored cruisers.											
Van Galen	Wood, 1872; unarmored cruiser; condition good	225	8	197 0	39 0	18 0	2,160	4	6.3	Krupp B. L	(?)
								6	4.72	do	4.72
Alkmar	Composite, 1874; unarmored cruiser; condition good	100	11	154 0	30 0	14 8	1,010	1	5.9	do	(?)
								6	4.7	Do.	

foreign ships of war—Continued.

AUSTRIA—Continued.

Battery.	Torpedo boats.	Weight of fire.			Armor.					Backing.		Remarks.
Position and mounting.		Ahead.	Broadside.	Astern.	Distribution.	Material.	Maximum thickness.	Minimum thickness.	Skin.	Material.	Thickness.	
							In.	*In.*	*In.*		*In.*	
Broadside, gun-deck			445									
Do.												
do			445									
Do.												
(?)			(?)									
(?)			(?)									
(?)			(?)									
(?)			(?)									
(?)			(?)									
(?)			(?)									
(?)			(?)									
(?)			(?)									
(?)			(?)									
(?)			(?)									
(?)			(?)									Built by Armstrong & Co., England.

HOLLAND.

In turrets; 2 forward, 2 aft.		1,137	2,198	1,137	Belt complete; two turrets.	Iron	8					Turret armor, 12″.
In broadside; train nearly ahead and astern.												
In turret		1,234	1,234	(?)	Belt and one turret	do	8					Turret armor, 9″.
do		495	495	(?)	do	do	5.5	4.5				Do.
do		495	495	(?)	do	do	5.5	4.5				Do.
do		517	517	(?)	do	do	5.5	4.5				Do.
do		495	495	(?)	do	do	5.5	4.5				Do.
do		495	495	(?)	do	do	5.5	4.5				Do.
do		1,034	1,034	(?)	do	do	5.5	4.5				Do.
do		77	77		do	do	5	4				Turret armor, 6.9″ to 5″.
do		77	77		do	do	5	4				Do.
do		77	77		do	do	5	4				Do.
do		77	77		do	do	5	4				Do.
(?)			(?)									
(?)			(?)									

Characteristics of pri

HOLLAND—Continued.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.
Unarmored cruisers—Continued.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*	
Atjeh	Composite, 1876; unarmored cruiser, 1st class; condition good.	225	14	262 6	39 0	19 6	3,160	6 8	6.7 4.72	Krupp B. L. Do.
Tromp	Composite, 1877; sister ship to Atjeh	225	14	262 6	39 0	19 6	3,160	6 8	6.7 4.72	do
K. Emma der Nederlanden.	Composite, 1879; sister ship to Atjeh	225	14	262 6	39 0	19 6	3,160	6 8	6.7 4.72	do
De Ruyter	Composite, 1880; sister ship to Atjeh	225	14	262 6	39 0	19 6	3,160	6 8	6.7 4.72	do
Van Speyk	Composite, 1882; sister ship to Atjeh	225	15	262 6	39 0	19 6	3,160	6 8	6.7 4.72	do
Doggersbank	Sister ship to Atjeh; building	225	15	262 6	39 0	20 0	3,160	6 8	6.7 4.72	do
J. Willem Friso	do	225	15	262 6	39 0	20 0	3,160	6 8	6.7 4.72	do
Also a large fleet of gun-vessels and small gunboats.										

DENMARK.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.
Armored vessels.										
Helgoland	Iron, 1878; battle-ship; casemate and turret; two masts; military tops; deck, 3″ thick; condition good.	300	13.3	267 0	58 0	18 6	5,347	1 4 5	12 10 4.72	Krupp B. L. do do
Iver Hvitfeldt	Battle-ship of smaller type; building	.....	.....	.....	.....	.....	3,260	6	(?)	.....
Gorm	Iron, 1870; single-turreted monitor; two masts; ram; condition good.	.....	12.3	231 6	39 0	14 5	2,344	2	10	Armstrong
Odin	Iron, 1872; low freeboard casemate; two masts; ram; condition good	.....	12.4	236 10	48 0	14 1	2,083	4	10	do
Tordenskjold	Iron, 1880; armored; turreted torpedo ship; condition good.	.....	14.5	221 6	43 0	15 0	2,420	1 6	14 4.72	Krupp B. L.
(Not named)	Armored; turreted; similar ship; building	.....	14.5	221 6	43 0	15 0	2,420	1 6	14 4.72	do
Unarmored cruisers.										
Fyen	Composite, 1882; unarmored cruiser, 2d class; condition good.	.....	.....	226 4	46 0	18 0	2,596	18	6	Krupp
St. Thomas	Wood, 1871; unarmored cruiser, 3d class; condition good.	.....	13	223 0	32 10	17 0	1,572	1 4	8 6	Armstrong B. L.
Ingolf	Iron, 1876; unarmored gun-vessel; condition good	.....	10	190 0	26 2	12 5	870	3	6	Krupp B.
Also a considerable fleet of gunboats.										

NORWAY.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.
Armored vessels.										
Scorpionen	Iron, 1865; single-turret monitor; condition fair	.....	7	164 0	44 0	11 4	1,447	2	10½	Armstr
Mjoelner	Iron, 1867; single-turret monitor; condition fair	82	8	168 5	42 0	11 3	1,566	2	10½	do.
Thrundvang	Iron, 1868; single-turret monitor; condition fair	.....	8.8	176 7	46 0	12 0	1,600	2	10½	do.
Thor	Iron, 1872; single-turret monitor; condition good	.....	9	176 7	46 0	12 0	1,660	2	10½	do
Odin	do	.....	9	176 7	45 0	12 0	1,660	2	10½	do
Unarmored vessels.										
Sleipner	Iron, 1877; unarmored gun torpedo boat; five tubes for discharging Whiteheads; one in bow, four in cranes on side; condition good.	.....	12	165 0	32 0	9 6	580	1 1	10½ 6	Krup Pall
Ellida	Iron, 1880; unarmored gun torpedo boat; five tubes for discharging Whiteheads; one in bow, four in cranes on side; condition good.	.....	12	165 0	32 0	9 6	580	1 1	10½ 6	Kru Pal
Also a considerable fleet of small gunboats.										

foreign ships of war—Continued.

HOLLAND—Continued.

Battery.		Weight of fire.			Armor.					Backing.		
Position and mounting.	Torpedo boats.	Ahead.	Broadside.	Astern.	Distribution.	Material.	Maximum thickness.	Minimum thickness.	Skin.	Material.	Thickness.	Remarks.
							In.	In.	In.		In.	
(?)			(?)									
(?)			(?)									
(?)			(?)									
(?)			(?)									
(?)			(?)									
(?)			(?)									
(?)			(?)									
DENMARK.												
In turret, forward. In casemate, 2 bow fire. On spar-deck, 1 stern, 4 broadside fire.		1,991	2,128	1,311	Belt complete; casemate; turret.	Iron	12	10				Built in Denmark; turret armor, 10″.
(?)			(?)		(?)							
In turret, forward		803	803		Belt complete; turret.	Iron	7					Turret armor, 7.9″.
In casemate		803	803	803	Belt; rectangular redoubt.	do	7.9	5			10.3	Casemate armor, 8″.
In turret, forward	Two	1,155	(?)	(?)	Turret and deck	do	7.8					Water-line, cork belt; turret, 7.8″.
do	do	1,155	(?)	(?)	do	do	7.8					Do.
In broadside		(?)	772	(?)								
(?)		(?)	336	(?)								
(?)		(?)	(?)	(?)								
NORWAY.												
In turret		800	800		Monitor type, belt and turret.	Iron	5				26	One turret forward; armor, 11.8″.
do		800	800		do	do	5				26	Do.
do		800	800		do	do	5				26	Do.
do		800	800		do	do	7				9	One turret forward; armor, 14″.
do		800	800		do	do	7				9	Do.
In fixed three port turret forward.		411	411	(?)								
do		411	411	(?)								

Characteristics of principal

SWEDEN.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Armored vessels.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*		
Svea	Iron; small type turret battle-ship; one mast; derricks and military top; protective deck, 2" thick; building.	142	13	226 0	48 8	15 6	2,662	2	10	Armstrong B. L.	21.6
								3	6	....do	8.5
J. Ericsson	Iron, 1865; single-turret monitor, "Passaic" type; condition fair.										
Thördon	.....do	.....	7	204 0	46 0	11 10	1,550	2	9.5	Finsprong B. L.	9.61
Tirfing	.....do										
Loke	.....do										
Seven monitor type	Iron, 1870–'72; armored gunboats; condition good	.....	8	106 0	26 2	8 2	460	1	9½	B. L.	9.61
Three casemate	.....do	.....	4.6	104 0	22 4	5 5	260	1	8	....do	.....
Unarmored cruisers.											
Balder	Wood, 1870; unarmored cruiser; condition good	216	13	203 5	36 0	19 6	1,873	4	6.5	B. L.	6.38
								2	.....	30-pounder, B. L.	
Saga	Wood, 1878; unarmored cruiser; condition good	188	13	196 10	32 10	18 4	1,617	2	6.5	Finsprong B. L.	6.38
								6	4.8	....do	
Freja	Steel; unarmored cruiser, new type; building	.....	.....	220 0	41 0	16 6	2,400	4	6.5	....do	6.38
								2	.....	30-pounder (?)	
Also a considerable fleet of unarmored gunboats.											
Dratt	Iron, 1877; torpedo vessel; condition good	.....	13	170 0	26 2	9 6	638	1	4.8	Finsprong B. L.	.....

TURKEY.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Armored vessels.											
Messudieh	Iron, 1874; broadside casemate battle-ship; belt; ship rig; deck, 1" thick; condition good.	.....	13.7	332 0	59 0	25 0	9,140	12	10	Armstrong	12.36
								2	7	....do	7.42
								1	7	....do	7.42
Hamidieh	Iron, 1885; broadside casemate battle-ship; belt; ship rig; deck, 1" thick; condition good.	640	13	292 0	55 9	25 6	7,920	10	9.45	Krupp	10.35
								2	6.7	....do	8.42
Idjilalieh (Majestic.)	Iron, 1870; armored cruiser, casemate surmounted by barbette tower; brig rig; condition good.	.....	11	213 3	42 8	17 0	2,228	1	9	Armstrong	9.84
								4	7	....do	7.42
Fethi Bulend	Iron, 1870; armored cruiser, old type; belt and casemate; ship rig; sides cut away for fore and aft fire; condition good.	219	12.5	235 0	43 0	18 0	2,760	4	9	....do	9.84
Mukademé-i-hair	Iron, 1872; sister ship; condition good	219	12	235 0	43 0	18 0	2,760	4	9	....do	9.84
Hesber	Iron, 1875; river monitor, one turret; condition good	51	7	134 6	30 8	5 6	652	2	4.72	Krupp	4.72

GREECE.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Hellas	Wood, 1878; unarmored corvette; condition good	.....	.....	200 1	39 4	14 9	1,650	6	6	Krupp	6.4
Amiral Miaulis	Composite, 1879; new type unarmored cruiser; condition good.	220	13.5	246 0	35 5	17	2,300	4	6.7	....do	8.42
Hydra	Steel, 1881; gunboat, type of Chinese "Epsilon;" protective deck; condition good.	.....	9	124 0	29 6	5 6	440	1	10.2	....do	15.95
Spetzia	Steel, 1881; sister ship; condition good	.....	9	124 0	29 6	5 6	440	1	10.2	....do	15.95
Alpheos	Iron, 1884; gunboat; bark rig; condition good	.....	10	137 0	25 0	.....	420	2	3.8	....do	.....
Eurotos	.....do	.....	10	137 0	25 0	.....	420	2	3.8	....do	.....
Perseos	.....do	.....	10	137 0	25 0	.....	420	2	3.8	....do	.....
Achelos	.....do	.....	10	137 0	25 0	.....	420	2	3.8	....do	.....

foreign ships of war—Continued.

SWEDEN.

Battery.	Torpedo boats.	Weight of fire.			Armor.					Backing.		Remarks.
Position and mounting.		Ahead.	Broadside.	Astern.	Distribution.	Material.	Maximum thickness.	Minimum thickness.	Skin.	Material.	Thickness.	
							In.	*In.*	*In.*		*In.*	
In turret			(!)		Belt complete; one turret; bulkhead.	Steel	12	10		Teak	11	Building at Stockholm; by Government.
In turret		634	634	(!)	Monitor type; belt and turret.	Iron	5			Wood	31½	One turret; armor, 10.7″; iron.
In turret		317			Belt and one turret	Iron	3			do	33⅞	One turret; 12″ armor.
In casemate; bow fire.		(!)			Belt and casemate; armored on forward side.	do	2.4			do	33⅞	On bulkhead protecting gun, 8.6″.
(!)			(!)									
(!)			(!)									
(!)			(!)									
(!)												Carries nine 15″ Whitehead torpedoes, submerged tubes.

TURKEY.

In casemate On forecastle. On poop.		229	2,382	114	Belt complete and casemate 135′ long.	Iron	12	9		Teak	12	Built at Thames Iron Works, England.
In casemate One forward, one aft; pivots.		(!) 128	1,457	(!) 128	(!)	do	10	6				Built at Constantinople.
In barbette tower In casemate.			476		Belt complete; casemate surmounted by barbette tower on after end.	do	6	4½				Built at Trieste; barbette armor, 4½″.
do		495	495	495	Belt complete; casemate.	do	9	6		Teak	10	Built in England.
do		495	495	495	do	do	9	6		do	10	Do.
In turret		77	77	(!)	Belt and turret	Iron	3			Teak	5½	Built in Constantinople.

GREECE.

In broadside		(!)	223	(!)								
One in bow, one in stern, two in sponsons.		383	383	383								Built in France.
In bow, protective shield.		634	(!)	(!)								Built in England
do		634										Do.

Characteristics of principal

PORTUGAL.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Armored vessel.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*		
Vasco de Gama	Iron, 1876; cruiser; belt; overhanging central casemate; barkentine rig; condition good.	130	12.5	216 0	40 0	19 0	2,479	2	10¼	Krupp	11.9
								1	5.9	do	
Unarmored vessels.											
Reine de Portugal	Composite, 1875; unarmored corvette; condition good.			170 0	26 0	14 9	1,124	2	7	Armstrong	7.42
								6		40-pounder Armstrong.	
Mindello	Composite, 1876; sister ship; condition good			170 0	26 0	14 9	1,124	2	7	do	7.42
								6		40-pounder Armstrong B. L.	
Alfonso de Albuquerque.	Iron, 1884; new type unarmored cruiser; condition good.			205 0	33 0	18 0	11,111	2	6	Armstrong B. L.	8.7
								4		40-pounder Armstrong B. L.	
								1		do	
12 gunboats	1873–1884; condition good						539–339?	1	7	Armstrong	
								4		40-pounder Armstrong.	

BRAZIL.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Armored vessels.											
Riachuelo	Steel, sheathed; 1883; armored cruiser; belt and two turrets; ship rig; steel protective deck, 2″ thick; condition good; 5 torpedo ports.	250	16	305 6	52 0	20 0	5,791	4	9	20-ton Armstrong B. L.	19.6
								6	5¾	Armstrong B. L.	14.1
Aquidaban	Steel, sheathed; 1885; similar to Riachuelo		*16	280 0	52 0	18 0	5,000	4	9	20-ton Armstrong B. L.	19.6
								4	5¾	Armstrong B. L.	14.1
Javary	Iron, 1875; sea-going monitor; two turrets; two signal poles; condition good.	137	12	240 0	58 0	11 10	3,700	4	10¼	Whitworth M.L	
Solimões	do	111	13	240 0	58 0	11 10	3,700	4	10¼	do	
Sete de Setembro	Wood, 1874; cruising iron-clad, old type; belt and redoubt; schooner rig; condition fair.	185	11	220 0	46 6	12 6	2,179	4	9¼	do	
Unarmored cruiser over 4,000 tons.											
Cruzador "B"	Steel; new type cruiser; 1st class; ship rig; building.	450	15.5	270 0	47 4	18 6	4,023	4	8	12-ton Armstrong B. L.	14.4
Cruisers between 4,000 and 1,000 tons.								10	6	Armstrong B. L.	10
Trajana	Wood, 1873; corvette; ship rig; peculiar wedge-shaped model; condition good.	162	13	200 0	39 10	15 6	1,414	7	4.76	Whitworth M. L.	(?)
Guanabara	Wood, 1877; corvette; ship rig; condition good	257	12.5	200 0	41 2	17 10	1,911	9	6	do	(?)
Almirante Barroso	Wood, 1882; corvette; new type; condition good	317	12.5	235 0	37 0	17 0	(?)2,200	2		40-pounder Armstrong B. L.	8
								6		do	8
Gun-vessels and gunboats.											
Paranahyba	Wood, 1878; gun-vessel; bark rig; condition good	147	10	169 0	28 8	11 6	742	5	4.72	Whitworth M. L.	(?)
Traripe	Wood, 1879; river gunboat; condition good		6	131 0	22 4	5 0		1	5.3	do	(?)
Premiro de Marco	Wood, 1881; gun-vessel; bark rig; condition good	141	9	166 0	27 7	11 7	726	5	4.72	do	(?)
Imperial Marinheiro	Wood, 1883; gun-vessel; bark rig; condition good	141	9	166 0	27 7	11 7	726	6	4.72	do	(?)
Manaos	Wood, 1882; gunboat; brig rig; condition good	58	8	120 0	20 8	3 10	163	(?)			
Iniciadora	Iron, 1883; gunboat; condition good	51	9.5	114 10	25 10	5 0	263	2	6	Armstrong B. L.	10
Guarany	Wood, 1883; gunboat; condition good			113 0	26 0	5 6		2	4.72	do	8
Marago	Steel; gunboat; condition good		9.5	130 0	31 0	6 0	409	2	6	do	10
Cananea and three others of class.	do		8	114 10	25 10	4 0	200	2	6	do	10

* Official estimates.

Characteristics of principal

ARGENTINE REPUBLIC.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Armored vessel.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*		
Almirante Brown	Steel, sheathed; 1880; armored cruiser; belt and casemate; brigantine rig; protective deck, 3″ thick; condition good.	.....	14	239 6	49 2	20 0	4,200	8	8	Armstrong B.L	15.9
								6	.....	40-pounder Armstrong B. L.	.....
(Not named)	Steel; building in England	.....	*14	250 0	50 0	20 0	4,260	8	8	Armstrong B. L	15.9
								(?)	(?)	(?)	
Patagonia	Steel; (?); building	.....	*14	213 2	32 10	12 9	1,530	1	10	Armstrong B.L.	21.6
								3	6	....do	
Los Andes	Iron, 1874; monitor type; deck, 1″; condition good	.....	9	180 0	42 6	10 6	1,535	2	8	....do	.....
								2	4½		
El Plata	Iron, 1875; monitor type; deck, 1″; condition good	.....	9	180 0	42 6	10 6	1,535	2	8		.....
								2	4½		
Unarmored vessel.											
Maipu	Iron, 1880; torpedo ship (depot, convoy, and transport); unarmored; condition good.	.....	12	229 7	36 0	8 6	1,100	1	4½	B. L	.....

CHILI.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Armored vessels.											
Almirante Cochrane	Iron, 1874; armored cruiser; belt; casemate overhanging and cut away for fore and aft fire; bark; condition good.	271	12.8	204 0	46 0	19 8	3,560	6	8	B. L	14.4
Blanco Encalada	Iron, 1874; sister ship; condition good	271	12.8	204 0	46 0	19 8	3,560	6	8	....do	14.4
Huascar	Iron, 1864; low freeboard; single turret; short t. g. forecastle and poop cut off bow and stern fire; broadside guns on quarter deck unprotected; brigantine rig; condition fair.	195	11	196 0	35 6	16 0	2,032	2	8	... do	14.4
								4	.....	20-pounder Armstrong B. L.	.....
Unarmored cruisers.											
Esmeralda	Steel, 1883; new type unarmored; 1st class, cruiser; protective deck 1½″ steel; cork belt; condition good; two masts, armored tops.	.....	18½	270 0	42 0	18 6	2,920	2	10	Armstrong B. L	19.4
								6	6	....do	10
Magellanes	Composite, 1874; unarmored corvette; condition good.	166	11.5	190 0	27 0	13 0	772	2	.....	70-pounder Armstrong B. L.	.....
								2	.....	13-pounder Armstrong B. L.	
Pilcomayo	Wood, 1874; unarmored corvette; condition good	.....	10.5	171 0	27 4	.....	600	2	.....	70-pounder Armstrong B. L.	.....
								4	.....	40-pounder Armstrong B. L.	

CHINA.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Draught aft.	Dimensions. Displacement.	Battery. Number.	Battery. Caliber.	Battery. Type.	Battery. Power (inches of wrought iron at muzzle).
Armored vessels.											
Ting Yuen	Iron, 1881; armored; battle and cruising ship; turrets and belt; cork chambers forward and abaft belt; deck 3″ thick; brigantine rig; military top; central superstructure on deck; condition good.	300	15.4	298 6	59 0	20 0	7,430	4	12	Krupp	19.8
								2	5.8	....do	8.98
Chen Yuen	Iron, 1882; sister ship	300	15.4	298 6	59 0	20 0	7,430	4	12	... do	19.8
								2	5.8		8.98
Unarmored vessels.											
Nos. 1, 2, 3, 4, 5, 6 have no motive power.	Wood, 1883; floating batteries; condition good	.....	.....	134 5	36 1	11 10	.....	3	8	Armstrong B. L	15.9
Hae-An	Wood, 1872; old type frigate; condition fair	372	12	300 0	42 0	20 7	3,400	2	8.5	Krupp B. L	9.57
								20	4.72	....do	4.72
								4	5.9	... do	5.67

* Official estimate.

foreign ships of war—Continued.

ARGENTINE REPUBLIC.

Battery.	Torpedo boats.	Weight of fire.			Armor.					Backing.		Remark
Position and mounting.		Ahead.	Broadside.	Astern.	Distribution.	Material.	Maximum thickness.	Minimum thickness.	Skin.	Material.	Thickness.	
							In.	In.	In.		In.	
Six in casemate, one forward, one aft.	.....	300	(?)620	300	Belt, casemate, bulkheads.	.....	9	7	.....	.....	.....	
Three ahead or astern..												
.....	.....	.....	(?)	.....	....do	Compound	10	.....	.....	.....	.....	
(?)	.....	.....	(?)	.....	(?)	.....	(?)	.....	.....	.....	.....	
In turret.....	.....	360	360	(?)	Belt and turret	Iron	6	.....	.....	.....	.....	Turret armor, 8".
.....do	.....	.....	.....	.....	....do	....do	6	.....	.....	.....	.....	Do.
Carries a complete outfit of submarine mines.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	

CHILI.

In casemate; 4 have nearly bow fire, 2 stern fire.	.....	720	540	360	Belt complete; casemate.	Iron	9	4½	.....	Teak..	10	Built in England.
.....do	.....	720	540	360	....do	....do	9	4½	.....	..do ...	10	Do.
In turret.....	.....	.....	400	.....	Belt complete.....	....do	4½	2½	.....	..do ...	10	Do.
In broadside.....	.....	.....	.....	.....	One turret.							
Pivots; one forward, one aft.	.....	400	1,040	400	.....	.....	.....	.....	.....	.....	.....	Built in England. *Coal protection*, in wake of engines and boilers, and on protective deck, above them; steel shields for guns.
In broadside.												
(?)	.....	.....	(?)	.....	.....	.....	.....	.....	.....	.....	.....	
Pivots.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	

CHINA.

In two turrets	Two, 64 ft.	2,973	1,657	2,973	Belt 138' long	Compound	14	8	.....	Teak	14	Two large turrets in waist abreast, 12" thick; two small, one forward, one aft; light armor; built in Germany.
One forward, one aft, in turrets.	.....	.....	.....	.....	Four turrets.							
.....do	....do	2,973	1,657	2,973	....do	....do	14	8	.....	..do ...	14	Do.
(?)	.....	.....	(?)	.....	.....	.....	.....	.....	.....	.....	.....	
.....	.....	(?)	973	(?)	.....	.....	.....	.....	.....	.....	.....	Built at Shanghai.

Characteristics of principal

CHINA—Continued.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions.				Battery.			
				Length.	Breadth.	Draught aft.	Displacement.	Number.	Caliber.	Type.	Power (inches of wrought iron at muzzle).
Unarmored vessels—Cont.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*		
Yang Wei	Steel, 1881; new type gun-vessel; protective deck; superstructure in waist; condition good.	131	16.2	209 9	32 8	15 0	1,350	2	10	Armstrong B. L.	19.4
Chao-Yuen	Forecastle and quarter deck 4′ 8″ above water line.	.....	.....	.....	.....	.....	.....	4	4½	....do	.....
Techi Yuen	Steel, 1883; new type cruiser; unarmored; protective deck; condition good.	180	15	236 0	32 8	15 9	2,355	2	8.5	Krupp B. L	9.57
								1	5.9	....do	5.67
Nan Thin	.....do	.....	15	252 7	37 9	18 0	2,200	2	8.5	....do	9.57
Nan Shuin	Steel, 1884; sister vessel to Nan Shuin	.....	.....	.....	.....	.....	.....	8	4.72	... do	4.72
11 "alphabetical class" gunboats; iron-steel, 1876–1881		.....	9	118 6	27 0	7 6	319	1	11	26-ton Arm. M. L.	.....
		.....	9	120 0	30 0	8 0	400	1	11	*or* 35-ton Arm. B. L.	20.1
A large fleet of lightly armed gunboats.		.....	10.9	125 0	29 0	9 6	440	1	12.5	*or* 38-ton Arm. M. L.	

JAPAN.

Armored ships.											
Fu so	Iron, sheathed; 1877; armored cruiser; casemate and belt; ship rig; condition good.	425	14	28 8	47 6	18 3	3,740	4	9.4	Krupp B. L., 15¾ ton.	11.77
								2	6.7	Krupp B. L., 5½ ton.	6.3
Kongo	Composite, 1877; belted cruisers; belt covered by outside planking; bark rig; two ports forward for torpedoes, two in waist; condition good.	415	14	229 6	40 7	17 6	2,248	6	5.8	4-ton Krupp B. L.	6.73
								2	6.6	5½-ton Krupp B. L.	7.6
								1	6.6	....do	7.6
Hi-yei	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Protected cruisers.											
Tsu Kushi	Steel; small type protected cruiser; built for Chili; 2 masts; square rigged forward; guns protected by bullet-proof mantlets; condition good.	90	16.8	210	35	17	1,350	2	10	25-ton Armstrong B. L.	19.4
								4	4.8	Armstrong B. L.	.....
Noshi	Steel, 1885; new type cruiser; bark rig; 4 torpedo tubes; protective deck 2.48″ thick; new.	.....	15*	320 10	43	21 6	3,651	4	9.45	French B. L ...	13.3
								6	5.9	....do	.....
								1	5.9	....do	.....
Naniwa	Steel, 1885; cruisers of "Esmeralda" type; 2 masts; military tops; protective deck, steel 2″ to 3″ thick; all guns protected by steel shields; 2 torpedo tubes above water on each broadside; new.	.....	18*	300	46	18 6	3,600	2	10.2	28-ton Armstrong B. L.	23
								6	5.9	5-ton Armstrong B. L.	10
Takachiho	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Unarmed cruisers between 2,000 tons and 1,000 tons.											
Katsuragi	Composite, 1885; cruiser, 3d class; bark rig; torpedo tubes on each side; new.	249	13*	208	35	15	1,476	2	6.7	Krupp B. L	.....
								5	4.72	Do.	
Yamato	Composite, 1885; cruiser, 3d class; bark rig; torpedo tubes on each side; building.	249	.....	208	35	15	1,476	2	6.7	....do	.....
								5	4.72	Do.	
Musashi	.....do	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

* Official estimate.

foreign ships of war—Continued.

CHINA—Continued.

Battery.	Torpedo boats.	Weight of fire.			Armor.					Backing.		Remarks.
Position and mounting.		Ahead.	Broadside.	Astern.	Distribution.	Material.	Maximum thickness.	Minimum thickness.	Skin.	Material.	Thickness.	
							In.	*In.*	*In.*		*In.*	
In superstructure; one foreward, one aft.	.....	400	880	400	.....	.....	.....	.....	.....	.....	.....	Built in England.
In superstructure, broadside.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
In machine-gun proof turret, forward.	.....	432	545	113	.....	.....	.....	.....	.....	.....	.....	Built in Germany.
In machine-gun proof turret, aft.												
One forward, one aft...	One.....	216	586	216	.....	.....	.....	.....	.....	.....	.....	Do.
In broadside.....	One.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Do.
In bow, trained by helm.	.....	462	.....	.....	.....	.....	.....	.....	.....	.....	.....	Built in England.
.....	.....	530										

JAPAN.

In casemate; 2 bow; 2 stern; 2 beam fire.	.....	816	698	816	Belt complete; casemate.	Iron	9	8	.....	.....	.....	Built in England.
In barbette.												
In broadside.....	.....	245	480	123	Belt ending short of bow and stern with armored bulkhead.	Iron	4½	4½	.....	.....	.....	Do.
Under forecastle.												
Pivot under poop.												
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
Pivots; one forward, one aft.	.....	400	800	400	.....	.....	.....	.....	.....	.....	.....	Do.
Broadside.												
In sponsons, 2 forward, 2 aft.	.....	712	868	634	.....	.....	.....	.....	.....	.....	.....	Built in France.
Broadside.												
Pivot, forward.												
Pivots, one forward, one aft.	.....	500	1,240	500	.....	.....	.....	.....	.....	.....	.....	Built in England.
Broadside.												
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
(?)	.....	.....	(?)	.....	.....	.....	.....	.....	.....	.....	.....	Built in Japan.
(?)	.....	.....	(?)	.....	.....	.....	.....	.....	.....	.....	.....	Building in Japan.
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Do.

Characteristics of principal

JAPAN—Continued.

Name of ship.	Descriptive and explanatory remarks.	Crew, officers and men.	Maximum trial speed.	Dimensions.				Battery.			
				Length.	Breadth.	Draught aft.	Displacement.	Number.	Caliber.	Type.	Power (inches of wrought iron at muzzle).
Unarmored cruisers between 2,000 and 1,000 tons—Continued.			*Knots.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Tons.*		*Inch.*		
Kai-mon	Wood, 1882; cruiser, 3d class; bark rig; condition good.	248	12.5	200 4	32 5	15 10	1,436	1	6.7	Krupp B. L.	.....
								6	4.72	do	.....
Gun-vessels.											
Seiki	Wood, 1875; bark rig gun-vessel; condition good	152	11	192 2	29 8	13 1	980	1	5.9	do	6.73
								4	4.72	do	4.72
Iwaki	Wood, 1878; bark rig gun-vessel; condition good	108	10	146 3	25 3	.....	610	2	4.72	do	4.72
								1	3.9	Do.	
Dispatch vessels.											
Jin-Gei	Wood, 1876; imperial yacht; schooner rig; paddle steamer; condition good.	119	.....	246	30 6	.....	1,792	2	.....	.....	.....
Amagi	Wood, 1877; dispatch vessel; bark rig; condition good.	140	11	196 6	29 8	.....	908	1	5.9	Krupp B. L.	.....
								4	4.72	Do.	

foreign ships of war—Continued.

JAPAN—Continued.

Battery.	Torpedo boats.	Weight of fire.			Armor.					Backing.		Remarks.
Position and mounting.		Ahead.	Broadside.	Astern.	Distribution.	Material.	Maximum thickness.	Minimum thickness.	Skin.	Material.	Thickness.	
							In.	*In.*	*In.*		*In.*	
Pivot			233									Built in Japan.
Broadside.												
Pivot			155									Do.
Broadside.												
			(1)									Do.
(1)												Do.
			155									Do.

WAINWRIGHT KELLOGG,
Lieutenant U. S. N.,
J. C. COLWELL,
Lieutenant U. S. N.,
Staff Intelligence Officers.

Approved:
R. P. RODGERS,
Lieutenant U. S. N., Chief Intelligence Officer.
July, 1885.

INCLOSURE B.

Depths of water on bars.

[In many of the harbors the shifting nature of the bottom or the engineering works in progress make constant changes in the depths. The depths given are the latest officially authenticated.]

Name.	Depth of water on bar at mean low water.	Mean rise and fall of tides.
ATLANTIC PORTS.	*Feet.*	*Feet.*
Calais, Me	8	23
Eastport, Me	48	18
Machias, Me	.....	.....
Rockland, Me	**21	9.6
Belfast, Me	**13	9.7
Bangor, Me	**13	9.7
Bucksport, Me	39	9.7
Camden, Me	**19	9.8
Bath, Me	30	7
Portland, Me	††21	8.9
Saco, Me	3	8.2
Portsmouth, N. H	36	8.6
Newburyport, Mass	6	7.8
Rockport, Mass	31	8.6
Gloucester, Mass	††19	8.9
Salem, Mass.***	21	9.2
Marblehead, Mass	27	9.5
Lynn, Mass	.....	.....
Boston, Mass	21	9.4
Plymouth, Mass.***	7	9.3
Barnstable, Mass	7	9
Provincetown, Mass	36	9.2
Nantucket, Mass.***	4	3.1
Edgartown, Mass.***	17	2
Wood's Holl, Mass.***	21	1.6
Vineyard Haven, Mass	20	1.7
New Bedford, Mass.***	16	3.7
Newport, R. I.***	19	3.9
Bristol, R. I	††21	4.7
Fall River, Mass	16.5	4.7
Providence, R. I.*	20	5.1
Stonington, Conn.***	14	2.6
New London, Conn.***	21	2.5
New Haven, Conn	12	6
Bridgeport, Conn	6	6.5
New York, N. Y	23	4.8
Perth Amboy, N. J	14	5.4
Little Egg Harbor, N. J	8	3.4
Atlantic City, N. J	7	3.9
Lewes, Del	††19	3.5
Wilmington, Del	20	5.7
Chester, Pa	20	5.7
Philadelphia, Pa	20	6.0
Norfolk, Va	21	2.7
Richmond, Va	†13	2
Washington, D. C	19	‡1.4
Annapolis, Md	19	0.9
Baltimore, Md	24	1.0
Edenton, N. C	8	.....

Name.	Depth of water on bar at mean low water.	Mean rise and fall of tides.
ATLANTIC PORTS—continued.	*Feet.*	*Feet.*
Plymouth, N. C §	8	.....
New Berne, N. C.§	10	.....
Beaufort, N. C.§	14	.....
Wilmington, N. C	8	4.5
Smithville, N. C	14	4.5
Georgetown, S. C	7.5	3.6
Charleston, S. C	14	5.1
Port Royal, S. C	21	6.5
Savannah, Ga	†9	7
Saint Mary's, Fla	11	8
Fernandina, Fla	11	7.5
Jacksonville, Fla	9	4.5
Saint Augustine, Fla	10	6.0
Key West, Fla	30	1.3
GULF PORTS.		
Tampa, Fla	21	1.5
Cedar Keys, Fla	9	2.5
Saint Mark's, Fla	6.5	.....
Apalachicola, Fla	15	2
Pensacola, Fla	19.5	1
Mobile, Ala.‖	18	.....
New Orleans, La	¶26	0.6
Galveston, Tex	12(?)	1.1
Brazos de Santiago, Tex	6	.....
Clarksville, Tex	.....	.....
Brownsville, Tex	.....	.....
PACIFIC PORTS.		
San Diego, Cal	21	4.8
San Luis Obispo, Cal	††19	4
Monterey, Cal	††19	3.4
Santa Cruz, Cal	††19	4.1
San Francisco, Cal	33	3.6
Vallejo, Cal	21	6
Benicia, Cal	25	6
Mendocino City, Cal	30	3.7
Trinidad, Cal	27	4.9
Crescent City, Cal	**14	4.7
Santa Barbara, Cal	**19	.....
Empire City, Oreg	10	4.5
Newport, Oreg	9	7.8
Portland, Oreg	**17	.....
Kalama, Oreg	**15	3.2
Astoria, Oreg	21	7
New Dungeness, W. T	36	7
Olympia, W. T	21	12
Seattle Harbor, W. T	**25	12
Steilacoom, W. T	††28	9.2
Port Townsend, W. T	††30	4.6

* Dredged channel. † Shoalest part of river. ‡ To Greenleaf Point. § Water level affected by freshets and winds.
‖ A dredge channel in course of construction marked by piles. ¶ At head of Passes. ** To wharf. *** Inner harbor.
†† Close to landing.

INCLOSURE C.

LIST OF VESSELS CLASSIFIED ACCORDING TO DRAUGHT OF WATER

AND

THE PORTS WHICH THEY CAN ENTER.

CLASS A OF FOREIGN VESSELS.
VESSELS DRAWING 25 FEET AND OVER.

CLASS B OF FOREIGN VESSELS.
VESSELS DRAWING FROM 20 FEET TO 25 FEET.

CLASS C OF FOREIGN VESSELS.
VESSELS DRAWING FROM 15 FEET TO 20 FEET.

CLASS D OF FOREIGN VESSELS.
VESSELS DRAWING LESS THAN 15 FEET.

LIST OF VESSELS CLASSIFIED ACCORDING TO DRAUGHT OF WATER AND THE PORTS WHICH THEY CAN ENTER.

CLASS A.—FOREIGN VESSELS DRAWING TWENTY-FIVE FEET AND OVER.

Vessels of Class A, drawing between 26 feet and 30 feet, can enter the following-named ports at half tide:

Eastport, Me.; Rockland, Me ; Belfast, Me.; Bucksport, Me.; Camden, Me.; Bath, Me.; Portland; Me.; Portsmouth, N. H.; Rockport, Mass.; Gloucester, Mass. (outer harbor); Marblehead, Mass.; Provincetown, Mass.; New Bedford, Mass. (outer harbor); Newport, R. I. (outer harbor); New London, Conn. (lower harbor); Fort Pond Bay, L. I.; Gardiner's Bay, L. I.; Napeague Bay, L. I.; Smithtown Bay, L. I.; Huntington Bay, L I.; Oyster Bay, L. I.; Hampton Roads, Va.; Key West, Fla.; Santa Barbara, Cal.; Monterey, Cal.; San Luis Obispo, Cal.; Santa Cruz, Cal.; Crescent City, Cal.; San Francisco, Cal.; Benicia, Cal.; Trinidad, Cal.; Mendocino City, Cal.; New Dungenness, Wash.; Olympia, Wash.; Seattle, Wash.; Steilacoom, Wash.; Port Townsend, Wash.

Vessels of Class A, drawing from 25 feet to 26 feet, can enter the following-named ports at half tide, in addition to those above mentioned:

Salem, Mass ; Boston, Mass.; Hempstead Bay, L. I.; New York; Lewes, Del. (breakwater); New Orleans, La.

CLASS B.—FOREIGN VESSELS DRAWING FROM TWENTY TO TWENTY-FIVE FEET.

Vessels of Class B, drawing less than 25 feet and more than 24 feet, can enter the following-named ports at half tide, in addition to those before mentioned:

Baltimore, Md.; Port Royal, S. C.; Vallejo, Cal.; Astoria, Oreg.

Vessels of Class B, drawing less than 24 feet and more than 23 feet, can enter the following-named ports at half tide, in addition to those before mentioned:

Bristol, R I.; San Diego, Cal.

Vessels of Class B, drawing less than 23 feet and more than 22 feet, can enter the following-named ports at half tide, in addition to those before mentioned:

Providence, R.I.; Norfolk, Va.; Wilmington, Del.; Chester, Pa.; Philadelphia, Pa.

Vessels of Class B, drawing less than 22 feet and more than 21 feet, can enter the following-named ports at half tide, in addition to those before mentioned:

Wood's Holl, Mass ; Tampa, Fla.

Vessels of Class B, drawing less than 21 feet and more than 20 feet, can enter the following-named ports at half tide, in addition to those before mentioned:

Vineyard Haven, Mass.; Pensacola, Fla

CLASS C.—FOREIGN VESSELS DRAWING FROM FIFTEEN TO TWENTY FEET.

Vessels of Class C, drawing less than 20 feet and more than 19 feet, can enter the following-named ports at half tide, in addition to those before mentioned:

Calais, Me.; Nantucket, Mass. (outer harbor); Washington, D. C.; Annapolis, Md.

Vessels of Class C, drawing less than 19 feet and more than 18 feet, can enter the following-named ports at half tide, in addition to those before mentioned:

Edgartown, Mass.; Fall River, R. I.; Mobile, Ala.; Kalama, Oreg.

Vessels of Class C, drawing less than 18 feet and more than 17 feet, can enter the following-named ports at half tide, in addition to those before mentioned:

Bangor, Me.; Portland, Oreg.

Vessels of Class C, drawing less than 17 feet and more than 16 feet, can enter the following-named ports at half tide, in addition to those before mentioned:

Perth Amboy, N. J.; Charleston, S. C.; Smithville, N. C.; Apalachicola, Fla.

Vessels of Class C, drawing less than 16 feet and more than 15 feet, can enter the following-named ports at half tide, in addition to those before mentioned:

Stonington, Conn.; New Haven, Conn.; St. Mary's, Fla.

CLASS D.—FOREIGN VESSELS DRAWING LESS THAN FIFTEEN FEET.

Vessels of Class D, drawing less than 15 feet and more than 14 feet, can enter the following-named ports at half tide, in addition to those before mentioned:

Richmond, Va.; Beaufort, N. C.; Fernandina, Fla.

Vessels of Class D, drawing less than 14 feet and more than 12 feet, can enter the following-named ports at half tide, in addition to those before mentioned:

Plymouth, Mass.; Barnstable, Mass.; Savannah, Ga.; Saint Augustine, Fla.; Galveston, Tex.; Newport, Oreg.; Empire City, Oreg.

Vessels of Class D, drawing less than 12 feet and more than 8 feet, can enter the following-named ports at half tide, in addition to those before mentioned:

Newburyport, Mass.; Bridgeport, Conn.; Little Egg Harbor, N. J.; Atlantic City, N. J.; Edenton, N. C.; Plymouth, N. C.; New Berne, N. C.; Wilmington, N. C.; Georgetown, S. C.; Jacksonville, Fla.; Cedar Keys, Fla.

CLASS A.—*Foreign vessels drawing twenty-five feet and over.*

NOTE.—Sister ships, of same draught, are bracketed.

Name of ship.	Maximum draught.
	′ ″
ENGLAND.	
Armored.	
Sultan	27 11
Devastation	27 6
Thunderer	
Rodney	27 3
Howe	
Benbow	27 3
Camperdown	
Anson	
Renown	27 3
Sanspareil	
Téméraire	27 2
Dreadnaught	26 9
Triumph	26 7
Alexandra	26 6
Nelson	26 6
Superb	26 5
Inflexible	26 4
Collingwood	26 3
Colossus	26 3
Edinburgh	
Neptune	26 1
Swiftsure	26 1
Northampton	25 9
Imperieuse	25 6
Warspite	
Unarmored.	
Shah	26 8
Inconstant	25 6
FRANCE.	
Armored.	
Friedland	29 11
Trident	29 10
Colbert	28 6
Richelieu	27 10
Marceau	27 3
Hoche	
Magenta	
Neptune	
Amiral Duperré	26 9
Charles Martel	26 8
Brennus	
Amiral Baudin	26 0
Formidable	
Duguesclin	25 3
Vauban	
Unarmored.	
Tourville	25 3
Duquesne	
ITALY.	
Armored.	
Italia	30 6
Lepanto	
Andrea Doria	
Ruggiero di Lauria	29 8
Francesco Morosini	
Re Umberto	28 11
Sicilia	
Dandolo	28 0
Duilio	
Palestro	25 5
Principe Amadeo	
RUSSIA.	
Armored.	
Admiral Nakimoff	25 9
Alexander II	
Minin	25 6
Vladimir Monomack	25 0
Dmitri Donskoi	
Moskwa	25 0
Admiral Arkass	25 0
Catharine II	25 0
Sinope	
Tcheame	
GERMANY.	
Armored.	
Kaiser	26 0
Deutschland	
SPAIN.	
Armored.	
Vitoria	27 4
Numancia	26 7
Sagunto	25 11
AUSTRIA.	
Armored.	
Custoza	26 9
Tegetthof	26 7
Kaiser	26 3
Erzherzog Albrecht	25 3
K. Erzherzog Rudolf	25 3
TURKEY.	
Armored.	
Hamidieeh	25 6
Messudieh	25 0

CLASS B.—*Foreign vessels drawing from twenty to twenty-five feet.*

Name of ship.	Maximum draught.
ENGLAND.	
Armored.	
Ajax	24 0
Agamemnon	
Conqueror	24 0
Hero	
Audacious	23 8
Invincible	
Iron Duke	
Rupert	23 7
Shannon	23 6
Orlando	22 6
Undaunted	
Australia	
Narcissus	
Galatea	
Polyphemus	21 3
Belle Isle	21 1
Orion	
Unarmored.	
Raleigh	24 7
Hecla	24 3
Bacchante	23 9
Boadicia	23 8
Euryalus	23 3
Rover	23 0
Iris	22 1
Mercury	22 0
Leander and 3 others of class.	20 6
Mersey and 3 others of class.	20 0
FRANCE.	
Armored.	
Dévastation	24 11
Foudroyant	
Redoutable	24 10
Turenne	24 10
Bayard	
Terrible	24 7
Requin	
Indomptable	
Caïman	
La Galissonnière	23 10
Victorieuse	22 8
Triomphante	
Thétis	21 10
Tonnerre	21 4
Fulminante	
Furieux	
Unarmored.	
Sfax	24 8
Naïde	23 —
Dubordieu	22 8
Iphigénie	22 4
Aréthuse	21 7
Duguay-Trouin	20 6
ITALY.	
Unarmored.	
Flavio Gioia	21 6
Amerigo Vespucci	
RUSSIA.	
Armored.	
Peter Velikij	24 9
Not named	23 0
General Admiral	23 0
Herzog Edinburgh	23 0
GERMANY.	
Armored.	
Preussen	24 7
Friedrich der Grosse	
Hansa	21 7
Unarmored.	
Leipzig	21 7
Prinz Adalbert	
SPAIN.	
Armored.	
Zaragoza	24 11
Not named	24 8
Mendez Nunez	22 0
Unarmored.	
Aragon	24 0
Castilla	
Navarra	
Reina Cristina	21 0
Reina Mercedes	
Alfonso XII	
AUSTRIA.	
Armored.	
Ferdinand Max	21 6
D. Juan d'Austria	20 9
Kaiser Max	
Prinz Eugene	
Hapsburg	(?)
Salamander	(?)
Unarmored.	
Radetzky	23 7
Laudon	
Fasana	20 4
Donau	20 0
Saida	
JAPAN.	
Unarmored.	
Noëbi	21 6

CLASS C.—*Foreign vessels drawing from fifteen to twenty feet.*

Name of ship.	Maximum draught.
	′ ″
ENGLAND.	
Armored.	
Torpedo ram (Polyphemus type, not named).	19 9
Glatton	19 3
Cyclops	16 4
Gorgon	
Hecate	
Hydra	
Unarmored.	
Calypso	19 11
Calliope	
Opal and 5 others of class	19 7 to 18 8
Comus and 8 others of class	19 3 to 18 6
Modeste and 4 others of class	18 4 to 17 6
Thetis	17 6
Tenedos	16 10
Heroine and 6 others of class	15 9
FRANCE.	
Armored.	
Tigre	19 7
Bouledogue	
Tempête	16 9
Vengeur	
Tonnant	
Unarmored.	
Champlain	18 9
Du-petit-Thouars	18 8
Lapérouse	18 8
Nielly	
Primauguet	
D'Estaing	
La Clocheterie	18 8
Fabert	18 4
Sané	18 4
Seignelay	
Forfait	17 3
Villars	
Roland	
Magon	
Rigault de Genouilly	17 1
Éclaireur	17 0
Vaudreuil	16 1
Hugon	15 11
Kerguelen	
Beautemps Beaupré	15 6
Duchaffaut	
Condor	15 5
Épervier	
Faucon	15 5
Vautour	
ITALY.	
Unarmored.	
Stromboli	19 4
Etna	
Tripoli	
Grito	
Vesuvio	19 0
Giovanni Bausan	18 6
Savoia	17 0
Christoforo Colombo	16 8
Staffetta	15 5
RUSSIA.	
Unarmored.	
Pamjat Markurija	19 8
Vitiaz	18 0
Rinda	
Africa	17 0
Europa	17 0
Krejser	16 6
Asia	16 6
Opyt	16 0
Dzigit	15 8
GERMANY.	
Armored.	
Sachsen	19 8
Bayern	
Wurtemburg	
Baden	
Oldenburg	19 6
Unarmored.	
Bismarck	19 8
Blücher	
Stosch	
Moltke	
Gneisnau	
Stein	
Freya	19 0
Carola	18 4
Olga	
Marie	
Sophie	
Ariadne	17 1
Luise	
Alexandrina	16 5
a Not named	
b Not named	
c Not named	(†)
d Not named	
AUSTRIA.	
Unarmored.	
Zrinyi	17 8
Aurora	
Frundsberg	
HOLLAND.	
Armored.	
K. der Nederlanden	19 0
Unarmored.	
Doggersbank	20 0
J. Wilham Friso	
Atjeh	19 6
Tromp	
K. Emma der Nederlanden	
De Ruyter	
Van Speyk	
Van Galen	18 0
DENMARK.	
Armored.	
Helgoland	18 0
Iver Hvitfeldt	17 6
Tordenskjold	15 0
Sister ship	
Unarmored.	
Fyen	18 0
St. Thomas	17 0
SWEDEN.	
Armored.	
Svea	15 6
Unarmored.	
Balder	19 6
Saga	18 4
Freja	16 6
TURKEY.	
Armored.	
Fethi Bulend	18 0
Mukademi-i-hair	18 0
Idjilalieh	17 0
GREECE.	
Unarmored.	
Amiral Miaulis	17 0
PORTUGAL.	
Armored.	
Vasco de Gama	19 0
Unarmored.	
Alfonso de Albuquerque	18 0
BRAZIL.	
Armored.	
Riachuelo	20 0
Aquidaban	18 0
Unarmored.	
Crusador "B"	18 6
Guanabara	17 10
Almirante Barroso	17 0
Trajana	15 6
ARGENTINE REPUBLIC.	
Armored.	
Almirante Brown	20 0
Not named	20 0
CHILI.	
Armored.	
Almirante Cochrane	19 8
Blanco Encalada	
Huascar	16 0
Unarmored.	
Esmeralda	18 6
CHINA.	
Armored.	
Ting Yuen	20 0
Chen Yuen	
Unarmored.	
Hae-An	20 7
Nan Thin	18 0
Nan Shuin	
Techi Yuen	15 9
Yang Wei	15 0
Chao Yuen	
JAPAN.	
Armored.	
Fu So	18 3
Kon Go	17 6
Hi Yei	
Unarmored.	
Naniwa	18 6
Takachiho	
Tsu Kushi	17 0
Kaimon	15 10

CLASS D.—*Foreign vessels drawing less than fifteen feet.*

Name of ship.	Maximum draught.
	′ ″
ENGLAND.	
Unarmored.	
Wild Swan and 11 others of class	14 10 to 14 3
Fantome and 5 others of class	14 7 to 13 11
Scout	14 6
Fearless	
Archer and 6 others of class	14 6
Dolphin	14 0
Wanderer	
Reindeer and 5 others of class	14 0
Arab	13 9
Rambler and 2 others of class	13 7
Lily	13 6
Flamingo and 3 others of class	13 2 to 12 11
Swallow and sister ship	12 0
Albacore and 2 others of class	11 6
Curlew	11 0
Landrail	
Redwing and 9 others of class	11 0 to 10 6
Swift	10 11
Linnet	
Coquette and 6 others of class	10 11 to 10 4
Cygnet and 11 others of class	10 9 to 10 6
Ariel	10 6
Zephyr	
Frolic and 3 others of class	10 0 to 9 6
Staunch and 27 others of class	6 9 to 6 1
Medina and 11 others of class	6 0
FRANCE.	
Armored.	
Achéron	11 10
Cocyte	
Phlegeton	
Styx	
Fusée	10 4
Grenade	
Mitraille	
Flamme	
Unarmored.	
Hussard	13 8
Dumont d'Urville	
Bouvet	12 10
Parseval	12 10
Milan	12 9
Bisson	12 9
La Bourdonnais	
Chasseur	
Voltigeur	
Inconstant	
Papin	
Fulton	
Boursaint	12 8
Volage	11 8
Comète	10 6
Gabes	
Lion	
Scorpion	
Météore	
Aspic	9 10
Vipère	
Lionne	9 6
Sagittaire	8 6
Capricorne	
Crocodile	9 4
Lutin	9 4
Lynx	
Étoile	8 4
Bombe	6 0
Couleuvrine	
Dague	
Dragonne	
Flèche	
Lance	
Sainte-Barbe	
Salve	
Alert and 7 of class	4 0
ITALY.	
Unarmored.	
Rapido	12 8
Scilla	12 6
Cariddi	
Pietro Micca	11 9
A. Barberigo	10 3
M. A. Colonna	
S. Veneiro	10 2
A. Provana	
Guardiano	5 11
Sentinella	
RUSSIA.	
Armored.	
Vice Admiral Popoff	14 0
Novgorod	13 2
Unarmored.	
Opritcnik	16 3
Razbojnik	14 11
Najezdnik	14 6
Zabijaka	14 4
Strelok	14 3
Plastun	14 0
Vjestnik	
Ingul	12 5
Jermak	11 0
Tungus	
Bobr	9 6
Sivoutch	
Wichr	7 8
Burun	7 2
Tuchu	
Kartech	
Bruja	7 2
Groza	
Grad	
Snjed	
Oltjow	
Doschd	7 1
Ersch	6 7
Jorsch	6 8
GERMANY.	
Armored.	
Brummer	10 6
Bremse	
Viper	10 2
Wespe	
Biene	
Scorpion	
Mücke	
Basilisk	
Camäleon	
Crokodil	
Natter	
Salamander	
Hummel	
Unarmored.	
Blitz	13 6
Pfeil	
Adler	.....
Zeiten	11 7
Habicht	11 5
Möwe	
Albatross	10 10
Nautilus	
Cyclops	9 10
Wolf	9 10
Hyäne	
Iltis	
SPAIN.	
Armored.	
Duque de Tetuan	6 11
Puigcerda	6 7
Unarmored.	
Jorge Juan	15 0
Sanchez Barcaiztegui	
Velasco	11 4
Conde del Venadito	
Cristobal Colon	
Don Juan de Austria	
Infanta Isabel	
Isabel II	
Ulloa	
Concha	.....
Elcano	
General Lezo	
Magellanes	
AUSTRIA.	
Armored.	
Maros	8 7
Leitha	
Unarmored.	
Panther	14 6
Sister ship	
Zara	13 9
Spalato	
Sebenico	12 0
Lussin	12 0
Albatross	11 10
Nautilus	
HOLLAND.	
Armored.	
Draak	11 0
Haai	9 10
Wesp	
Luipaard	
Panter	
Hyaena	
Matador	9 10
Isala	4 8
Rhenus	
Moza	
Merva	
Unarmored.	
Alkmar	14 8
Also a large fleet of gunboats	11 9 to 6 8
DENMARK.	
Armored.	
Gorm	14 5
Odin	14 1
Unarmored.	
Ingolf	12 5
Also a considerable fleet of gunboats	7 6 to 5 6
NORWAY.	
Armored.	
Thrundvang	12 0
Thor	
Odin	
Scorpionen	11 4
Mjoelner	11 3
Unarmored.	
Sleipner	9 9
Ellida	
Also a considerable fleet of gunboats	

CLASS D.—*Foreign vessels drawing less than fifteen feet*—Continued.

Name of ship.	Maximum draught.	Name of ship.	Maximum draught.	Name of ship.	Maximum draught.	Name of ship.	Maximum draught.
	′ ″		′ ″		′ ″		′ ″
SWEDEN.		Hydra	5 6	Paranahyba	11 6	CHILI.	
Armored.		Spetzia	5 6	Marago	6 0	*Unarmored.*	
J. Ericsson, Thordon, Tirfing, Loke	11 10	PORTUGAL.		Guarany	5 6	Magellanes	13 0
7 monitor-type gunboats	8 2	*Unarmored.*		Traripe	5 0	CHINA.	
3 casemate gunboats	5 5	Reina de Portugal, Mindello	14 9	Iniciadora	5 0	*Unarmored.*	
Unarmored.		12 gunboats	13 1 to 10 2	Cananea and 3 others of class	4 0	11 iron and steel gunboats (alphabetical class)	9 6 to 7 6
Dratt	9 6	BRAZIL.		Manaos	3 10	JAPAN.	
TURKEY.		*Armored.*		ARGENTINE REPUBLIC.		*Unarmored.*	
Armored.		Sete de Setembro	12 6	*Armored.*		Katsuragi, Yamato, Musashi	15 0
Hesber	5 6	Javary, Solimões	11 10	Patagonia	12 9	Seikf	13 0
GREECE.		*Unarmored.*		Los Andes, El Plata	10 6	Iwaki	(?)
Unarmored.		Primero de Marco, Imperial Marinheiro	11 7	*Unarmored.*		Jiu Gei	(?)
Hellas	14 9			Maipu	8 6	Amagi	(?)

INCLOSURE D.

CHARACTERISTICS OF PRINCIPAL PORTS

OF

THE UNITED STATES.

CHARACTERISTICS OF PRINCIPAL PORTS OF THE UNITED STATES.

[Compiled in the Office of Naval Intelligence—Bureau of Navigation, Navy Department.]

PART I.—FROM CALAIS, ME., TO PROVINCETOWN, MASS.

[NOTE.—All depths are estimated for mean low water. The range of the tides is the mean rise and fall.]

[The populations are taken from official census of 1880.]

CALAIS.

Center of large lumber business. It is connected with Saint Stephen, New Brunswick, by a covered bridge. It is 250 yards between ends of wharves of two towns. Population, 6,172. Depth at mean low water from bar to town, 8 feet. Depth at high water from bar to town, 31 feet. Mean rise of tide, 23 feet. Tide very swift. Sailing vessels must wait for a tow. It is five miles from bar to town. The bar or ledge is at Mark's Point. No anchorage in harbor. It is necessary to make fast to wharf. A branch of the New Brunswick Railroad is within range of both the inner moorings and outer anchorage.

EASTPORT.

Business: Fisheries and lumber. Harbor is not obstructed by ice during winter on account of strong current which breaks it up. Population, 4,006.

Deep water in almost any part of harbor. City can be approached to within any distance. Good anchorage in 3 to 6 fathoms in Quoddy Bay, distant 5 miles. The main entrance to bay, a good position from which to shell the town, is distant 5 miles. The other entrance to bay is Lubeck Straits; it is crooked and dangerous except to small vessels. Only 5 feet can be carried through at low tide.

Roads exposed to northeast winds, untenable in a gale. In such cases and in winter Brood Cove is used. Town could be shelled from channel or Quoddy Bay.

No railway near the town.

ROCKLAND.

Business: Lime, ship-building, lumber, and fisheries. Population, 7,599. Has an open harbor. Can carry 5 fathoms to within half a mile of wharf near center of city, and about 3 fathoms to wharves. Mean rise and fall of tide, 9.6 feet. Often closed during winter, both by ice of local formation and drift ice.

Open harbor; town could be shelled with ease.

Can anchor at almost any point in harbor. Best anchorage, for protection from bad weather, under lee of breakwater near Jamesson Point. There is an earthwork on this point.

The Knox and Lincoln Railroad terminates here, and is within easy range from any point in harbor. This connects with railroad to Portland.

BELFAST.

Business: Lumber, ice, and ship-building. Population, 5,308. Has an open harbor. Can carry 5 fathoms to within 1 mile of city, and 13 feet to wharves. Is closed, on an average, for several weeks every winter by ice; in severe winters for two or three months. East winds bring in drift ice.

Open harbor; town could be shelled with ease. Rise and fall of tide, 9.7 feet.

Inside anchorage is to southwest of Steel's Ledge, distant about half a mile from wharves.

The Belfast Branch of Maine Central Railroad, connecting with all parts of Maine, is about 1½ miles from best anchorage.

BANGOR.

Extensive lumber trade, large ice trade, and considerable ship-building. Is at head of navigation of Penobscot River. Population, 16,856. Can carry 14 feet to moorings. Channel is rapidly filling up with sawdust and slabs from lumber mills up the river. Mean rise of tide, 9.7 feet. The river is closed to navigation three months in the year by ice, and in severe winters for a longer period.

Can carry 5 fathoms to Crosby Narrows, within 4 miles of the city, which could be shelled from this position. The city is 30 miles up the Penobscot River.

The Bangor and Bucksport Railroad, connecting with all parts of the State, runs along right bank of river within easy range.

BUCKSPORT.

This port has a small fishing trade and some lumber trade and ship-building. Population, 3,433. Can carry 6 to 14 fathoms close to town. Strong current. Closed with ice during winter. Fort Knox is on point opposite town on steep bluff. Good anchorage. The town is 13 miles up Penobscot River.

Can approach within one-quarter mile of town with any draught. Could be easily shelled from almost any point on river.

There is a branch of Maine Central Railroad within easy range. It connects with all parts of State.

CAMDEN.

Trade: Lime, lumber, and fishing. Population, 4,386. Can carry 5 fathoms to one-half mile of town. Closed with ice during part of winter. Rise and fall of tide, 9.8 feet. Town is 13 miles from entrance of Penobscot Bay. Could be shelled from almost any position. No railroads.

BATH.

Has the largest ship-building and ship-owning interests in the State. Population, 7,874. City extends about 3 miles along river bank. Can carry 5 fathoms up to city. Mean rise and fall of tide, 7 feet. River is seldom closed by ice owing to strong current. Could be shelled from any point on river below city.

The Knox and Lincoln Railroad, connecting with Portland, crosses the river here by ferry, and is within easy range.

PORTLAND.

This port has extensive foreign and coastwise trade. Is the principal shipping port for Canada during the winter. Population, 35,080. The harbor is never obstructed by ice. Can carry 5 fathoms to within half a mile of wharves and 16 feet to wharves. Mean rise and fall of tide, 8.9 feet. Current never more than 1 knot. It has four entrances, but only one, the most southern, can be used except by small vessels, as the others are too crooked and shallow.

The city could be shelled from seaward from northeast of city to southeast, at distances varying from 3 to 4 miles, in more than 5 fathoms of water. There are several good anchorages between Long Island, Great Hog Island, and Peak's Island; also between Great Hog and mainland, all within easy range of city. There are several railroads, the principal being the Grand Trunk, connecting with the interior and with Canada, which are within easy range. There is also a good anchorage to the southward at Richmond Island Harbor, where vessels might anchor and attack the city.

RICHMOND ISLAND HARBOR.

There is a good anchorage in 5 fathoms of water, within three-eighths of a mile of breakwater, well protected from all directions except from south to west.

Being only a harbor of refuge, there is no settlement here. Harbor clear of ice during the year. Mean rise and fall of tide, 9.1 feet Vessels could anchor here and shell Portland, as it is only 6½ miles distant, or disembark a force and attack the city by land.

SACO.

There is no anchorage off town, as there is not sufficient draught of water; the channel is crooked, and at mean low water there is, at places, only 3 feet. Mean rise and fall of tide, 8.2 feet.

There is an anchorage, in 5 to 7 fathoms, in Saco Bay, distant 3½ miles from city, or at Winter Harbor, at mouth of river, 5½ miles from city, in 3½ to 8 fathoms. From either of these anchorages the town could be shelled. There is a town on opposite side of river called Biddeford, which is connected with Saco by several bridges. The Eastern Railroad and Boston and Maine Railroad both pass through town, connecting with interior of State and with Boston. Population, 6,389.

PORTSMOUTH.

Population, 9,690. The principal industries are in manufactories. Has considerable foreign and coastwise trade. The navy-yard is opposite the city, distant half a mile. The anchorage is good in almost any part of the bay, and 6 fathoms can be carried up to the city. In the narrow parts of channel the anchorage is not good on account of the strong current. The usual anchorage for vessels not going to city wharves or navy-yard is at Pepperell's Cove, in from 6 to 11 fathoms. The harbor is never closed by ice. Mean rise and fall of tide, 8.6 feet. Forts Constitution, McClary, and Sullivan are in a dilapidated condition and could do little to defend the harbor, and from their position could not prevent an enemy's fleet from shelling the city. An anchorage could be taken outside of Gerrish Island, distant less than 4 miles, in from 5 to 6 fathoms, and the city and navy-yard could be shelled with ease. The Eastern Railroad, and Concord and Portsmouth Railroad, connecting with Boston and with the State of Maine, are within range. The former crosses the river by a substantial bridge near north end of town.

NEWBURYPORT.

A manufacturing town. Population, 13,538. There is only 6 feet water on bar, and it is impossible for any but small vessels to enter. No ice except occasional drift-ice. Mean rise and fall of tide, 7.8 feet. The town could be shelled from the open sea, at a distance of 3 miles, in 5 fathoms of water. The Eastern Railroad crosses the river, and the bridge and railroad are within range. The Boston and Maine Railroad is also within range. The bar is being deepened.

ROCKPORT, MASS.

Extensive granite quarries. Large quantities of granite shipped. Population, 4,480. There is 8 fathoms of water in outer and 11 feet in inner harbor. No ice in winter. Mean rise and fall of tide, 8.6 feet. The inner harbor can only be used by small vessels. The town could be easily shelled at a distance from one-half to three-eighths of a mile, in 6 to 8 fathoms of water. Branch of Eastern Railroad, connecting with Boston Railroad, within easy range.

GLOUCESTER.

This port has the largest fishing industries in the United States; there are also granite quarries, and yards for building fishing schooners. Population, 19,329. Has good anchorage, in 5 fathoms, within three-eighths of a mile of town; in 3½ fathoms close to shore. Mean rise and fall of tide, 8.9 feet. The harbor is often frozen over in winter. Town could be easily shelled from entrance of harbor at a distance of 2½ miles, or over the land, near Brace's Cove, in 5 to 7 fathoms of water, at a distance of 1½ miles. A branch of Eastern Railroad to Salem passes through to Rockport, and is within range.

SALEM.

Has a number of manufactories, and has large coasting trade; also ships large quantities of ice. Population, 27,563. 4½ fathoms can be carried to Fort Pickering,

is small and not safe, and the inner one can only be entered by small vessels. The town can easily be shelled from almost any position outside. One branch of the Old Colony Railroad terminates here, and is within easy range.

BARNSTABLE.

Fishing is the principal occupation, and a number of coasting vessels are owned here. Population, 4,242. Only small vessels can enter the harbor. Rise and fall of tide, 9.3 feet. The town could be shelled from almost any point outside of harbor, at a distance of 3 miles. The Cape Cod Railroad is within easy range.

PROVINCETOWN.

The principal occupation is fishing. Population, 4,340. It has the finest harbor on the coast, with plenty of water. Mean rise and fall of tide, 9.2 feet. During severe winters the ice packs in harbor, and sometimes becomes 18 feet thick, and the harbor is not cleared until the spring; but as a rule it is clear. The town could be shelled from almost any position. The Cape Cod Railroad is within easy range.

PART II.—FROM NANTUCKET, MASS., TO PLYMOUTH, N. C.

NANTUCKET.

This is a summer resort, there being few industries. Population, 3,220. The inner harbor is closed by bar; there is a good anchorage in outer harbor. The harbor is closed almost every winter by drift-ice. Rise and fall of tide, 3.1 feet.

The town could be shelled either from north or south—from the northward at distance of 2 miles, and from southward at 4 miles, both in 5 fathoms.

EDGARTOWN.

The principal occupation is fishing. Population of township, 1,707. There are two harbors, the outer and the inner.

The inner harbor is small and narrow, but has an excellent anchorage with about 17 feet. The outer harbor has about 4 fathoms and good holding ground, but is open to the northward. Rise and fall of tide, 2 feet. The drift-ice often closes this harbor when the winds come strong from the northward, but the local ice seldom interferes with steam navigation.

The town could be shelled from several positions at a distance of 3 miles in outer harbor, in Muskegat Channel with 4 fathoms, or from position due south of town, distant 4 miles, in 5 fathoms of water.

WOOD'S HOLL.

Small town Population not given. 3¾ fathoms can be carried into harbor. The harbor is good, but small. Considerable drift-ice during winter. Local ice does not form on account of strong current, which sometimes runs as much as 5 knots. Town

could be shelled from the northward or southward at a distance of 1 mile, in 6 fathoms of water. The Cape Cod Railroad terminates here, and is within easy range. Rise and fall of tide, 4 feet on northern side, and 1 foot to southward of town.

VINEYARD HAVEN.

This is a summer resort. Has very small trade. Small population. Rise and fall of tide, 1.7 feet. The harbor is closed almost every winter by local and drift ice. Good harbor except during northerly winds. Could be easily shelled from seaward; distance 2 miles, in 5 fathoms water.

NEW BEDFORD.

This port has a large number of factories and a considerable whaling fleet. Population, 26,845. There are two harbors, the outer and the inner; 16 feet can be carried into the inner harbor by a crooked, narrow channel, and the outer is an open roadstead, with 4½ fathoms, and is 1½ miles from the city. During severe winters the harbor is closed by ice, but, as a rule, steamers can force their way through. The city can be shelled from the outer harbor or from almost any point to southward of city, but there would be great danger of strange vessels striking on some of the numerous reef and rocks which are at present well bouyed. There is a bridge crossing the river at Fairhaven, which is within range. The railroad leading to Boston and Fall River terminates here, and is within range. There are two forts, one on Fort Point and another on Clark Point. Mean rise and fall of tide, 3.7 feet.

FALL RIVER.

This port has a large number of manufactories, principally cotton mills. Has considerable coasting trade. Population, 48,969. 16½ feet can be carried to city. Has a good harbor and good anchorage. There is considerable ice during the winter, and during severe winters the harbor is closed to sailing vessels, but steamers can force their way through. Rise and fall of tide, 4.7 feet. It would be difficult for an enemy to approach the city close enough to shell it, for, although there is plenty of water to admit of an approach to within easy range, there are several narrows to be passed which could be easily defended. The nearest one, at Hog Island, is 6 miles from the city. There are several railroads entering the city. The one connecting with Newport runs along the shore, and is within easy range from the channel outside of Hog Island.

NEWPORT.

This port has a number of manufactories, the principal ones being cotton. Population, 15,693. Has a fine harbor, with water enough for the largest ships. 19 feet can be carried into the inner harbor. The harbor is sometimes closed by ice to sailing vessels, but steamers can always enter. The city could be easily shelled from almost any position outside, and a good anchorage taken. There is one railroad connecting the city and Fall River, which is within easy range.

BRISTOL.

This port has a number of manufactories. Population, 6,028. 21 feet can be carried to anchorage off lower end of town, one-quarter mile distant from shore, and 5 fathoms can be carried within 2 miles of town, with a good anchorage. Rise and fall of tide, 4.7 feet. During the winter the harbor is at times closed by ice for sailing vessels, but steamers can force their way through. The town could be easily shelled from almost any position, from the westward or southward, in 5 fathoms of water, at a distance of from 2 to 3 miles. The only difficulty would be to enter Narragansett Bay. If the entrances could not be defended, the whole interior of bay would be at the mercy of an enemy, who could easily cut off communication by railroad between Bristol, Newport, Providence, and Boston.

PROVIDENCE.

This is one of the principal manufacturing centers of the United States. Population, 104,857. Twenty feet can be carried through a dredged channel, 1½ miles long, to city; the remainder of the channel is narrow, and without pilot or buoys it would be impossible to enter. The harbor is not closed by ice to steamers. The nearest anchorage, in 5 fathoms, is 4½ miles distant. On account of shoals, the city could not be safely approached nearer than 6½ miles (Conimicut Point), if there were no pilots or buoys, and would be out of range, except for very high-powered guns; but Pawtuxet, a small place three miles below city, would be within range. There are a number of railroads, which connect with all parts of New England. Rise and fall of tide, 5.1 feet.

STONINGTON.

This is a manufacturing town. Population, 7,355. 8 feet can be carried alongside of wharf and 14 feet into inner harbor. There are three entrances, all of which are dangerous without pilot, lights, or buoys. There is a good anchorage outside, between Fisher's Island and mainland, in 9 to 13 fathoms, about 4 miles from town. The town could not be approached with safety, on account of shoals and rocks, nearer than two and a half miles, but from that distance, to the southward, or from inside Fisher's Island, at a distance of 3 miles, it could be easily shelled. The New York, Boston and Providence Railroad is within easy range. The harbor is sometimes completely closed by ice, but, as a rule, it can be entered. Rise and fall of tide, 2.6 feet.

NEW LONDON.

This is a manufacturing town, and also has whaling and fishing interests. Population, 10,537. Has one of the finest harbors in the United States, 3 miles long and 30 feet deep. The harbor is not closed by ice to steamers Rise and fall of tide, 2.5 feet. The city could be shelled from any point in harbor or from position, in 5 fathoms of water, inside Southwest Ledge, distant 2½ miles. There are four railroads connecting with New York, Boston, and all parts of New England, all within easy range.

NEW HAVEN.

Large number of manufactories. Has considerable trade. Population, 62,882. 12 feet can be carried up to city, and that through a very narrow channel. 5 fathoms can be carried to within 4 miles of city. The harbor is closed to sailing vessels by ice; but steamers, as a rule, can enter. The city could be shelled at a distance of 3 miles by light-draught vessels, and at 4 miles in 5 fathoms; both positions almost due south to near Southwest Ledge. New Haven is an important railroad center, and the railroads are within range. Rise and fall of tide, 6 feet.

BRIDGEPORT.

This port has extensive manufactories and considerable coasting trade. Population, 27,643. 6 feet can be carried up to the city through a narrow channel; 3½ fathoms to within 2 miles, and 5 fathoms to within 4 miles. Rise and fall of tide, 6.5 feet.

Harbor is closed by ice to sailing vessels, but steamers can, as a rule, enter. The city could be easily shelled from position to the southward, 2 to 4 miles distant. The New York, New Haven, and Boston Railroad is within easy range.

LONG ISLAND.

The principal occupation of the inhabitants is agriculture. With the exception of the cities near New York, all of the towns on the island are small. The island is quite thickly populated. There are a number of bays indenting the island, where good anchorages can be taken. The best are on the north shore, there being only two on the south side. Fort Pond Bay, Napeague Bay, Gardiner's Bay, Smithtown Bay, Huntington Bay on north shore, and Rockaway Inlet and Fire Island Inlet on south shore are the best anchorages.

Fort Pond Bay.—There is good anchorage in from 5 to 8 fathoms Bay open to northward.

Gardiner's Bay.—There is a good anchorage in from 3¾ to 5 fathoms. The bay is sheltered in all directions. 4½ fathoms can be carried to Greenport, where railroad terminates. Population of Greenport, 2,000.

Napeague Bay.—There is a good anchorage in from 5 to 8 fathoms. Bay open to northward.

Smithtown Bay.—There is a good anchorage in 4½ fathoms close to shore. Bay open to northward.

Huntington Bay.—There is good anchorage well inside in 5 fathoms. Beyond is Northport Bay, into which 3½ fathoms can be carried. Huntington Bay is open to northward.

Oyster Bay.—There is good anchorage in almost any part of bay, and 4 fathoms can be carried over bar. Well protected from all directions.

Hempstead Harbor.—There is good anchorage in 3¾ fathoms. Bay open to northward. Branches of Long Island Railroad run to Hempstead, Huntington, Port Jefferson, Glencoe, Sag Harbor, and the towns on Great South Bay and Jamaica Bay.

Rockaway Inlet.—15 feet can be carried into harbor.

Fire Island Inlet.—18 feet can be carried into harbor.

The small towns near these bays or harbors could be easily shelled from the anchorages, and an enemy could easily land at almost any point on north shore. There is plenty of water to within two miles of New York by way of the East River for any vessel, but the channel is narrow. To eastward of Willets Point the channel is wider, and Whitestone, Strattonport, and Flushing could be shelled from some position to northward of Willets Point. There is a large fort on Throg's Neck (Fort Schuyler).

A position could be taken in 30 feet of water, near Coney Island, and 8 miles from navy-yard, from which, with high-powered guns, Brooklyn, the lower part of New York, and the surroundings to southward could be shelled.

PERTH AMBOY.

Large quantities of coal are shipped from this port. It has some coastwise trade. Population, 4,405. Eleven feet can be carried to town. Mean rise and fall of tide, 5.4 feet. During severe winters the harbor is sometimes closed with ice, but steamers can force their way through.

The town could be shelled from a distance of 4½ miles in 19 feet, or at a distance of 6 miles in 25 feet of water.

The Long Branch Railroad crosses the river by bridge to South Amboy and is within range.

There are several railroads entering the town and are within range of vessels not drawing more than 25 feet.

The large quantities of coal that accumulate here could be destroyed by enemies' vessels.

LITTLE EGG HARBOR.

There is no large settlement near the harbor. Eight feet can be carried over the bar. Rise and fall of tide, 3.4 feet. The channels are crooked, and without buoys it would be impossible for a stranger to enter.

Almost any point of the harbor could be shelled from outside 2 or 3 miles distant in from 20 to 30 feet of water.

ATLANTIC CITY.

This place is a summer resort. Population, 5,077. Can be approached to within 3½ miles with 5 to 6 fathoms, and from this position the town could be easily shelled.

There is no harbor except for small vessels. There are three railroads, the Camden and Atlantic, Philadelphia and Atlantic City, and West Jersey; all within range.

LEWES.

A small town 2 miles to the southward and westward of Delaware Breakwater. Population, 1,400. From 4 to 5 fathoms can be carried under lee of breakwater, and from that position the town could be easily shelled. Rise and fall of tide, 3.5 feet.

The Delaware, Maryland and Virginia Railroad enters the town, and is within easy range.

WILMINGTON, DEL.

A manufacturing city. Iron-ship building, foundries, machine shops, and factories of various sorts. Du Pont's powder mills are situated about 2 miles from city. Population, 42,478. 20 feet can be carried up the Delaware River to the mouth of Christiana Creek, on which the city is situated, and 12 feet on Christiana Creek to the city. Rise and fall of tide, 5.7 feet. If vessels could succeed in getting up the Delaware River, the city could easily be shelled from the river at a distance of 2 miles. Several important railroads enter the city and all are within range.

Wilmington is 70 miles from mouth of bay.

CHESTER, PA.

Chester has many manufactories, also iron-ship building yards. Population, 15,000. 20 feet can be carried to city. If enemy's vessels could succeed in getting up the Delaware River, the city could be easily shelled from the channel at a distance of about one-half mile. There are two railroads, both within easy range. The Philadelphia and Wilmington Railroad runs along the right bank of the river, and is within easy range from any point in the channel between Chester and Wilmington.

Rise and fall of tide, 5.7 feet.

Chester is 82 miles from mouth of Delaware Bay.

HAMPTON ROADS.

Fort Monroe is the chief defense of the roads. Besides the garrison there is a small settlement outside the walls.

The town of Hampton, with a population of 2,300, is 2 miles to the northward and westward of the fort.

There is plenty of water for vessels of any draught from entrance of Chesapeake Bay to short distance of fort. 25 feet can be carried to Newport News, which is a growing shipping town.

Both Hampton and Newport News are within easy range from the Roads. There is a railroad to these places, and it is within easy range. Rise and fall of tide, 2.5 feet.

NORFOLK.

This port has a large commerce, principally in cotton. Population, 21,926. 21 feet can be carried to the city and navy-yard. Rise and fall of tide, 2.7 feet. The channel is narrow, and if there were no buoys or pilot the passage would be difficult. A position could be taken at entrance of channel to Norfolk in 27 feet, at a distance of 7 miles, if Hampton Roads could not be defended, and with high-powered guns the city and navy-yard could be shelled. A position could also be taken in 24 feet, in Lynn Haven Roads, at same distance, from which the city, navy-yard, and surrounding towns could be shelled. There are three railroads entering the city, or Portsmouth on opposite side of river, which are within range.

ANNAPOLIS.

This place has a population of 6,642. 19 feet can be carried over the bar. Rise and fall of tide, 0.9 foot.

The town and Naval Academy could be shelled from the inner roads in from 19 to 25 feet, at a distance of 2 to 3 miles, or from outer roads in 30 to 50 feet, at a distance of 4 miles. The Annapolis and Elk Ridge Railroad within range.

BALTIMORE.

A large commercial and manufacturing city. Population, 332,313. 24 feet can be carried to city through a dredged channel 12 miles long. Rise and fall of tide, 1 foot. Vessels not drawing more than 15 feet could approach the city to any distance, and it could be shelled from almost any position on Patapsco River below; but vessels drawing more than 15 feet would have great difficulty in approaching the city. Without a pilot, and if the buoys were removed, the nearest position that could be taken by vessels drawing more than 15 feet would be 14 miles from the city (owing to the numerous shoals).

There are a large number of important railroads entering the city.

WASHINGTON.

Population, 159,871. It is 200 miles from the ocean. 19 feet can be carried to city. The channel is narrow above Mount Vernon, 12 miles from city. The city could be shelled from almost any point on the river below.

The Washington and Alexandria Railroad and branch of Baltimore and Ohio Railroad run along the banks of the river, and are within range.

RICHMOND.

This is a large manufacturing city. Population, 63,600. 13 feet can be carried to city. Rise and fall of tide, 3.6 feet. It is on the James River, 150 miles from its mouth. 18 feet can be carried to City Point, 40 miles below the city. The river is quite narrow for a long distance below the city, and could be easily defended. Several railroads enter the city.

EDENTON, N. C.

A small town of 1,200 population. Only 8 feet can be carried from sea to town. Could be shelled from almost any position to southward. The Norfolk Southern Railroad terminates here, and is within range.

NEW BERNE, N. C.

This place has a few manufactories and ships lumber, tar, and turpentine. Population, 6,443. 10 feet can be carried to city, but only 8 feet can be carried over bar from sea into Pamlico Sound. The town could be shelled from almost any position on Neuse River, but only vessels of light draught could be of any use. The Atlantic and North Carolina Railroad passes through the town, and is within range from river, from 10 to 15 miles below the town.

PLYMOUTH, N. C.

A small town with coastwise trade. Cotton and lumber are shipped. Population, 1,387. 10 feet can be carried to town by river, but only 8 feet can be brought in from sea. Could be shelled from mouth of river, which is 5½ miles distant, or from almost any position on Roanoke River below the town. No railroad.

PART III.—FROM BEAUFORT, N. C., TO SAINT AUGUSTINE, FLA.

BEAUFORT, N. C.

A small town without any particular industries. Ships a small quantity of lumber and cotton. Population, 2,891. 14 feet can be carried over bar. Inside Fort Macon there is from 18½ to 30 feet with good anchorage, and 9½ feet can be carried to within one-fourth of a mile of town. The town could be shelled from position inside Fort Macon 1⅛ miles below by vessels drawing not more than 14 feet, and from position outside the bar, due south of town, 3 miles distant, in 36 to 40 feet. The Atlantic and North Carolina Railroad, which terminates at Morehead City, about 1 mile west of Beaufort, could be shelled from either inside or outside the bar.

WILMINGTON, N. C.

This port has considerable trade in lumber, cotton, and turpentine. Population, 17,250. The city is situated on the Cape Fear River, 30 miles above its mouth. 8 feet can be carried over outer bar at mouth of river and 7 feet in river channel to the city. None but very light draught vessels could approach the city close enough to shell it. There are three railroads entering the city. Rise and fall of tide, 4.5 feet.

SMITHVILLE, N. C.

A small town, with a population of 1,008. 14 feet can be carried over bar, and there is a very good anchorage off town in from 4 to 6 fathoms. Mean rise and fall of tide, 4.5 feet. The town could be shelled from almost any position on Cape Fear River, below, by vessels not drawing over 14 feet, and from outside, over the land, from a position about 3 miles southwest from town in 4 fathoms, or 4 miles in 5 fathoms. There is no railroad.

GEORGETOWN, S. C.

Ships lumber and turpentine. Population, 2,557. The town is situated 14 miles from the bar at entrance on Winyah Bay. 7½ feet can be carried to town. It could be shelled from almost any position on the bay by vessels drawing less than 7½ feet, but the channel is narrow and crooked, and without pilots or buoys it would be dangerous to venture into the bay. There is one railroad, the Georgetown and Lanes Railroad, which connects with railroads in the interior. Rise and fall of tide, 3.6 feet.

CHARLESTON, S. C.

This port has a large foreign trade. Ships large quantities of cotton, phosphate, naval stores. Population, 49,984. 14 feet can be carried over the bar of South

Channel, and inside 21 feet can be carried by South Channel to city. Mean rise and fall of tide, 5.1 feet. Without pilots or buoys great difficulty would be experienced in entering the harbor on account of the numerous shoals, but a position could be taken 7 miles from city, about southeast, in 25 feet of water, from which with high-powered guns the city could be shelled. Several railroads enter the city, but unless the harbor could be entered little harm could be done to them.

PORT ROYAL, S. C.

This port has a fine harbor, but there is only a small settlement near the Sound. Population, 347. 21 feet can be carried over bar. Rise and fall of tide, 6.7 feet. Beaufort, with a population of 2,547, is situated about 11 miles above the mouth of the Beaufort River, and 23 miles from outside bar. It has a small trade in phosphate and lumber. The settlement of Port Royal could be easily shelled from almost any position on sound or Beaufort River, and Beaufort could also be shelled from a distance of 5 or 6 miles, in 3½ fathoms of water.

The Port Royal Railroad terminates at the settlement and passes through Beaufort. It is within range.

SAVANNAH, GA.

A large commercial city, and ships in large quantities cotton, rice, lumber, and naval stores. Population, 30,790. 17 feet can be carried over the bar at mouth of Savannah River, and 9 feet to city. Mean rise and fall of tide, 7 feet. The city could not be approached nearer than 12 to 10 miles except with very light draught vessels, as the channel is narrow and crooked, and there would be great difficulty for any vessels to get up the river without pilots or buoys. It would be very difficult to take any position on the water from which the city could be shelled. There are several railroads entering the city, which connect with all the principal lines. Engineering works in progress promise greatly increased draught to city.

SAINT MARY'S, FLA.

A small town on Saint Mary's River, with a moderate lumber trade. Population, 1,375. 11 feet can be carried over the bar. After passing the bar 17 feet can be carried to town, a distance of 10 miles. Rise and fall of tide, 8 feet. Inside of bar there are several good anchorages in from 3½ to 7 fathoms.

A position could be taken about 6½ miles to eastward outside of harbor, in 3½ fathoms, from which the town could be shelled; or if the bar could be passed there is a good anchorage, in 6 to 7 fathoms, about 4 miles from town, from which it could be shelled. There are no railroads.

FERNANDINA, FLA.

Principal trade is in lumber. Population, 2,562. There is 11 feet on bar at entrance. Inside there is from 3½ to 9 fathoms, with good anchorage. Rise and fall of tide, 7.5 feet. The town could be shelled from a position outside, due east, at a

distance of 3½ to 4 miles in from 4½ to 5½ fathoms; or from inside bar, by light-draught vessels, due north in 5¾ fathoms, 2 miles distant. The Florida Railroad enters the town and is within range.

JACKSONVILLE, FLA.

This place has considerable lumber trade, and is a winter resort for invalids. Population, 7,650. 9 feet can be carried over bar and to town. Rise and fall of tide, 4½ feet. The town is on the Saint John's River, 20 miles from its mouth. The channel by the river to town is narrow, with short bends, and without pilots or buoys it would be almost impossible to approach near enough to shell it. There are four railroads entering the town.

SAINT AUGUSTINE, FLA.

A winter resort for invalids. Population, 2,293. Has a shifting bar; 10 feet can, as a rule, be carried over. Inside the bar there is good harbor to northward of town, with from 18 to 20 feet. Rise and fall of tide, 6 feet. The town could be shelled from outside of bar in from 4 to 5 fathoms, 2½ miles distant. There are two railroads within range, one running to Jacksonville and one connecting with the interior.

PART IV.—FROM KEY WEST, FLA., TO BROWNSVILLE, TEX.

KEY WEST, FLA.

The principal industries are cigar manufacture and sponge fisheries. Population, 10,000 to 15,000. There are several channels entering the harbor, the best being the main ship channel, through which 23 feet can be carried; 30 feet can be carried through the southwest channel, and 12 feet can be carried in from northwest channel. Rise and fall of tide, 1.3 feet. The town could be approached within 1½ miles by largest vessels from southward, and a good anchorage could be taken to shell it. Vessels lying outside the reef at a distance of 8 miles from town, in 5 fathoms, could shell the town and fleet lying in outer or inner harbors, if high-powered guns were used.

CEDAR KEYS, FLA.

This place is the terminus of the Florida Railroad, and has some trade in pine and cedar lumber. Population, 440. There are three channels to settlement. Sea Horse Key Channel is the deepest, there being 9 feet on bar. Rise and fall of tide, 2.5 feet. It would be difficult to approach the settlement closer than a position 6 miles to southward and westward in 3¾ fathoms, as there are so many shoals and reefs. Without pilot or buoys it would be dangerous, but from the position indicated the settlement and the railroad could be shelled with high-powered guns.

TAMPA BAY, FLA.

There is a small settlement at head of bay, 35 miles from entrance. Population, 720. Twenty-one feet can be carried through North Channel and up the bay 25 miles. Good anchorage in any part of bay. Vessels not drawing more than 8 feet

can anchor off the settlement, and it could be shelled by vessels of light draught, but vessels drawing more than 15 feet could not get within range. One railroad connecting with railroad to Jacksonville terminates here. Rise and fall of tide, 1.5 feet.

SAINT MARK'S, FLA.

Saint Mark's is the terminus of branch railroad to Tallahassee. Very small settlement. 6½ feet can be carried up to settlement, but channel is narrow and crooked. Enemy's vessels could not reach the village without pilots or buoys, and the nearest good anchorage is over 10 miles distant in about 3½ fathoms. One railroad from Tallahassee enters the settlement.

APPALACHICOLA, FLA.

A shipping port for lumber. Population, 1,326. 15 feet can be carried over the bar at entrance of bay by the West Pass and 4 feet to town. Rise and fall of tide, 2 feet. The town could be shelled from the bay from almost any position by very light-draught vessels, or from a position south of town outside of Saint George's Island in 5 fathoms, distant 7 miles. No railroad.

PENSACOLA, FLA.

Ships large quantities of lumber. Population 6,845. 19½ feet can be carried over the bar. Rise and fall of tide, 1 foot. Vessels drawing less than 19½ feet could with ease shell the city, the navy-yard, and the towns of Warrington and Woolsey. A position could be taken outside of Santa Rosa Island in 5 fathoms of water, distant 6 miles from the city, from which it could be shelled with high-powered guns. A position could be taken outside of Santa Rosa Island, in 5 fathoms, distant about 2 miles, from which the navy-yard, Warrington, and Woolsey could be shelled. There are two railroads connecting with the interior and with ports to eastward and westward, within range.

MOBILE, ALA.

Mobile has a large shipping trade in cotton and lumber. Population, 29,132. Nineteen and a half feet can be carried over bar at entrance of bay, and 18 feet can be carried through dredged channel 21 miles long to city. The city is 30 miles from outer bar. In case of an enemy's vessel attempting to enter, the dredged channel could be closed and none but very light-draught vessels could approach close enough to the city to shell it. Vessels drawing less than 16 feet could with safety approach within 4 miles of the city, and could shell it from any position on bay to southward. There is a good anchorage several miles inside the outer bar, with 3½ fathoms. There are four railroads connecting with principal coast ports and with the interior.

NEW ORLEANS, LA.

Large commercial city; shipping large quantities of cotton and grain. Population, 216,090. The channel through the South Pass is 26 feet deep and 300 feet wide, having a central depth of 30 feet without regard to width.

Through Southwest Pass 15 feet and Southeast Pass 7 feet can be carried. The city is 110 miles from the sea and could be shelled from the river 2 miles below English Turn, at a distance of 6 miles; or vessels could anchor directly off the city. It could also be approached from the rear by vessels of very light draught (5 feet) by the way of Lake Pontchartrain, and shelled with ease. The railroad connecting with Mobile is within easy range from Lake Borgne. There are a number of railroads entering the city, which are within easy range from river.

GALVESTON, TEX.

This place ships large quantities of cotton and is the most important commercial city in Texas. Population, 22,248. Eleven feet can be carried over outer bar and 9½ feet can be carried to city wharves. Rise and fall of tide, 1.2 feet. The city could be shelled from seaward at a distance of 3 miles in 30 feet of water. It would be unnecessary to cross the bar in order to shell the city. There are three railroads entering the city, and they and the bridge crossing the bay are within range. From information derived from Mallory & Co., their steamers can carry from 13 to 13½ feet over Galveston bar. At times they can carry 14 feet, but such occasions are very are (this at high water).

BRAZOS SANTIAGO, TEX.

A small settlement. Six feet can be carried over bar, and alongside of wharves there is 21 feet. The settlement could be shelled from seaward at a distance of 2 miles in 6 fathoms of water. There is a railroad leading to Brownsville which terminates at Point Isabel on opposite side of bay, 4 miles distant; could be shelled with high-powered guns from outside of bar.

CLARKSVILLE, TEX.

No reliable information can be obtained, as there is no chart of harbor or entrance to Rio Grande River.

BROWNSVILLE, TEX.

Situated on the Rio Grande 35 miles from its mouth. Has population of 4,905. It has considerable river commerce, and is connected with Point Isabel by the Rio Grande Railroad.

No information can be obtained about the approaches by the river, as there are no charts finished.

PART V.—THE PACIFIC COAST PORTS.

PORT TOWNSEND, WASH

A small town with a little trade and fisheries. Population, 918. Has a very fine harbor, and 5 to 9 fathoms can be carried close to shore opposite the center of town. Rise and fall of tide, 4.6 feet. The town could be shelled from any position

in harbor or from outside in Puget Sound at any distance from one-fourth of a mile to greatest range possible. There is no railroad.

STEILACOOM, WASH.

A small town with some lumber trade. Population, 600. Has a fine harbor with great depth of water; from 6 to 15 fathoms can be carried to within one-fourth of a mile of the town. Rise and fall of tide, 9.2 feet. The town could be shelled from any position in harbor. There is one railroad, the Northern Pacific, which passes 4 miles from town, and is within range from harbor.

SEATTLE HARBOR, WASH.

This place has large trade in lumber and supplies for lumbering district, also has some manufactories. Population, 3,533, and growing rapidly. Has a very fine harbor with 4½ fathoms to wharves, and plenty of water at anchorage off town. Rise and fall of tide, 12 feet. The town could be shelled from any position in harbor; 6 to 11 fathoms could be carried within one-fourth mile of town. One railroad—the Columbia and Puget Sound Railroad, connecting with Northern Pacific Railroad—enters the town and is within range.

OLYMPIA, WASH.

Olympia is the capital of Washington Territory. Has a few manufactories and ships lumber. Population, 1,272. 3½ fathoms can be carried to within 1½ miles of town; inside of that the bay shoals rapidly to a large mud flat in front of town, which is uncovered at low tide. Rise and fall of tide, 12 feet. Could be shelled from almost any position in Budd's Inlet, over 1½ miles from town, and in from 3¾ to 8 fathoms of water. A branch of the Northern Pacific Railroad enters the town and is within range.

NEW DUNGENESS, WASH.

A small post station. Very small population. Has a good harbor with from 5 to 15 fathoms, but is open to eastward. Rise and fall of tide, 7 feet. There is nothing to shell on shore except the light-house, but vessels at anchor in harbor would be within easy range from any position outside, with plenty of water. No railroad.

ASTORIA, OREG.

This place has large establishments for canning salmon. Population, 2,803. 21 feet can be carried over bar at mouth of Columbia River, and from there to town (14 miles) there is over 28 feet. Rise and fall of tide, 7 feet. It would be dangerous for strange vessels to enter the river without pilot or buoys, on account of shifting sand on bar; but a position could be taken due west of town, at a distance of little over 6 miles, in 5 fathoms of water, from which the town could be shelled, over the land, near Point Adams; or, having entered the river, the town would be within range from channel after passing between Cape Disappointment and Point Adams. No railroad.

Sometimes there is 27 feet of water on bar; but it is very shifting, and the depth varies. During winter months there is at times a very heavy breaking sea on the bar, preventing the passage of all vessels for several days.

KALAMA, OREG.

A small town on Columbia River, 70 miles from mouth. 15 feet can be carried to its wharf. Rise and fall of tide, 3 feet. If no attempt were made to defend the river, an enemy not drawing more than 17 feet could ascend it, and the town could be shelled from any position below not farther than 2 miles. (It would be necessary to be within 2 miles on account of a bend of the river.) The steamers connect here with the Northern Pacific Railroad, which passes through the town and skirts along the north bank of river, and is within easy range at almost any point 6 miles below the town.

PORTLAND, OREG.

Portland is situated on the Willamette River, 12 miles from the Columbia and 112 miles from the sea. Has a few manufactories, and exports lumber, grain, and wool. Population, 17,577.

No reliable information can be obtained about the exact amount of water that can be carried to city, but the steamers from San Francisco ascend the river to its wharves. When the river is in good condition 19 feet can be carried to the wharves, but in August and September only 17 feet, according to reports of masters of San Francisco steamers. It would be very difficult for an enemy to ascend the river without a pilot, and the river could be so well defended that it is not likely that an enemy would venture to go so far from the sea. There are two railroads, both branches of the Northern Pacific. These, with the town, could be easily destroyed if no resistance were made on the river below the city.

NEWPORT, OREG.

A very small settlement about 1 mile from bar, on Yaquina River. Population, 59. The bar is continually shifting, both in position and depth, and one-half mile outside of bar is a reef running north and south, on which the sea breaks at low water. As a rule 9 feet can be carried over bar. Inside of bar there is from 3½ to 6¾ fathoms. Rise and fall of tide, 7.8 feet.

If vessels could pass bar the settlement could be shelled from almost any position inside, but if not wishing to pass it could be shelled from position close inshore in from 4 to 5 fathoms, between 2 and 3 miles distant. No railroad.

EMPIRE CITY, OREG.

A small place 4 miles up Coos Bay. Population, 420. 10 feet can be carried over bar, but it is shifting constantly both in position and depth. After passing bar, 17 feet can be carried to town. Rise and fall of tide, 4.5 feet. Strong currents. Light-

draught vessels could enter the bay and shell the town from almost any position above Fearless Rock; or vessels could take a position due west of town, distant about 2 miles, in more than 5 fathoms, and shell the town, over the sand hills, between the bay and the ocean. No railroad.

CRESCENT CITY, CAL.

This small place has lumber trade. Population of township, 1,281. Is a dangerous harbor to enter, and it should not be attempted without a pilot, on account of numerous shoals and rocks. 25 feet can be carried to anchorage near Whaler's Island, and 14 feet to wharf. Rise and fall of tide, 4.7 feet. Could be shelled from almost any position to southward, at distance of over 1¼ miles, in more than 5 fathoms. No railroad.

TRINIDAD, CAL.

A small town, with some trade along the coast. Ships redwood lumber. Population, 104. 42 feet can be carried to outer anchorage, 27 feet to moorings inside of Prisoners' Rock, and 14 feet to wharves. Rise and fall, 4.9 feet. Town could be shelled from seaward at a distance of 1½ to 2 miles, in more than 6 fathoms of water. No railroad. Harbor is open to southward.

MENDOCINO, CAL.

Mendocino has considerable trade in lumber. Population of township, 3,125. Has an open harbor with from 5 to 6 fathoms at anchorage, one-third of a mile from settlement. 13 to 18 feet can be carried to wharves. Rise and fall of tide, 3.7 feet. The town and several lumber mills are within easy range from almost any position, with plenty of draught of water. No railroad.

BENICIA, CAL.

A small town at the head of ship navigation. Contains United States Arsenal, several small manufactories. Population, 1,794. 25 feet can be carried up San Pablo Straits to town, and at anchorage there is 33 feet. Rise and fall of tide, 6 feet. If San Francisco Bay could be safely entered by an enemy and the channel up the bay not defended, Benicia could be shelled from almost any position in Karquines Straits. The Central Pacific Railroad crosses the straits from Benicia to Martinez by ferry, and is within easy range from the straits.

VALLEJO, CAL.

Vallejo is situated on opposite side of Napa Creek from navy-yard, 27 miles north of San Francisco. Population, 5,987. 21 feet can be carried to anchorage between the town and navy-yard. Rise and fall of tide, 6 feet. If entrance to San Francisco Bay and channel up the bay to Mare Island could not be defended, both Vallejo and the navy-yard would be at the mercy of an enemy, as they could easily be shelled

from almost any position in channel below Mare Island, but with a sufficient number of modern guns the channel could very easily be defended. A branch of Central Pacific Railroad skirts along shore near Vallejo, and is within range from channel.

SAN FRANCISCO, CAL.

The largest and most important commercial and manufacturing city on the Pacific coast. Population, 233,959. The harbor is one of the finest in the world. 33 feet can be carried over bar to city and almost any part of bay. Rise and fall of tide, 3.6 feet. With the present state of the defenses the bay could be entered by an enemy's fleet, and the city, Oakland, and several other small places on bay could be shelled. If the entrance were properly defended, the city could be shelled with high-powered guns from outside the bay near Port Lobos, in over 5 fathoms of water, at a distance of from 6 to 7 miles. There are a number of railroads entering the city that could be shelled from the bay.

SANTA CRUZ, CAL.

A small town on San Lorenzo River, about 1 mile from its mouth. Population, 3,898. The harbor is an open one. The anchorage is good in from 3¼ to 6 fathoms. It is well protected, except from southward and westward. The town could be easily shelled from seaward or from the roadstead. The Santa Cruz Railroad is within easy range, also the South Pacific Coast Railroad. Rise and fall of tide, 4.1 feet.

MONTEREY, CAL.

A small summer resort. Population, 1,102. Has a fine harbor and good protection from all but northerly winds. There is a good anchorage in from 3½ to 15 fathoms within one-half mile of shore. It could be easily shelled from almost any point in the harbor. There is one railroad within easy range. Rise and fall of tide, 3.4 feet.

SAN LUIS OBISPO, CAL.

The harbor is an open one to the southward. The town is about 8 miles in the interior, to the northward of bay. The population of town is 2,243. There is only a small settlement on bay. There is a good anchorage in from 3 to 5 fathoms. The bay is open to the southward. The town is out of range of any except very high-powered guns. The Pacific Coast Railroad is within easy range. Rise and fall of tide, 4 feet.

SANTA BARBARA, CAL.

Exports large quantities of wool and fruit. Population, 3,460. Has a harbor open to the southward. Large islands 25 miles to southward furnish a partial shelter. There is 20 feet at anchorage near wharf and 19 along side. Thick kelp extends out about one-half mile; inside of this the anchorage is good. In the winter it is not a safe anchorage. The town could be easily shelled from any position to seaward, the bay being perfectly open. No railroad.

SAN DIEGO, CAL.

Exports hides and wool. Population, 2,637. 21 feet can be carried over the bar, and there is plenty of water to anchorage off town. Rise and fall of tide, 4.8 feet.

The town could be shelled from outside the island in from 25 to 30 feet, distant about 2 miles, or from almost any position to southward outside the harbor. The California Southern Railroad connects here with South Pacific Railroad and is within range.

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INCLOSURE E.

STUDY OF EXPOSED POINTS ON OUR FRONTIER,

LINES OF COMMUNICATION AND POSSIBLE BASES OF HOSTILE OPERATION.

[From the files of the Office of Naval Intelligence.]

STUDY OF EXPOSED POINTS ON OUR FRONTIER—LINES OF COMMUNICATION AND POSSIBLE BASES OF HOSTILE OPERATION.

[From the files of the Office of Naval Intelligence.]

* "Fortifications must close all important harbors against an enemy and secure them to our commercial and military marine; they must deprive an enemy of all strong positions, where, protected by naval superiority, he might fix permanent quarters on our territory, maintain himself during the war and keep the whole frontier in perpetual alarm; they must cover the great cities from attack; they must prevent as far as practicable the great avenues of interior navigation from being blockaded at their entrance into the ocean; they must cover the coastwise and interior navigation by closing the harbors and the inlets from the sea which intersect the lines of communications and thereby aid the navy in protecting the navigation; and finally, they must protect the great naval establishments."

The object of this paper is to consider the coastwise and frontier lines of communication in regard to the exposed points where an enemy may have advantages for invasion or to establish bases of operation. The nature and extent of the frontier and coast require that the different portions of the frontier be separately considered according to the exigencies of the frontier to be defended. The subject is therefore divided, for considering separately each portion of the United States frontier and coast, as follows, viz:

I. The Canadian and Lake region.
II. The New England and Atlantic seaboard.
III. The Gulf coast and Mexican frontier; and
IV. The Pacific coast and Northwest frontier.

I. The Canadian and Lake Region.

The Canadian frontier defenses are to be considered in the event of war with England, and the facilities possessed by the lines of communications in both countries will materially operate to the advantage of the country which has the most ample means of transportation for troops and supplies.

† "The United States and Great Britain are equally prohibited by treaty stipulations from building or keeping afloat a fleet of war vessels upon the lakes. At the same time, on the shores of these lakes the United States have many wealthy cities and

* Bernard's and Totten's Report, 1826. Copied from Thesis by First Lieut. T. H. Bliss, First Artillery.
† Report of House Military Committee, 1862.

towns and upon their waters an immense commerce; these are unprotected by any defenses worthy of special notice, but are as open to incursion as was Mexico when invaded by Cortez.

"A small fleet of light-draught, heavily-armed armored gun-boats could in one month, despite of any opposition that could be made by extemporized batteries, pass up the Saint Lawrence into the lakes and shell every town and city from Ogdensburg to Chicago. At one blow it could sweep our commerce from that entire chain of waters. To be able to strike a blow so effective Great Britain constructed a canal around the Falls of Niagara. By this single stroke the entire chain of lakes was opened to all British light-draught ocean vessels. Perceiving our ability to erect works upon the Saint Lawrence that might command its channel and thus neutralize all they had done, Great Britain dug a canal from the foot of Lake Ontario, on a line parallel to the river, but beyond the reach of American guns, to a point on the Saint Lawrence below, beyond American jurisdiction, thus securing a channel to and from the lakes out of our reach. Occupied by our vast commercial enterprises and by violent party conflicts our people failed to notice at the time that the safety of our entire northern frontier has been destroyed by the digging of two short canals. Near the head of the Saint Lawrence the British, to complete their supremacy on the lakes, have built a large naval depot for the construction and repair of vessels, and a very strong fort to protect the depot and the outlets of the lake—a fort which cannot be reduced, it is supposed by them, except by regular approaches. The result of all this is that in the absence of ships of war on the lakes and of means to convey them there from the ocean, the United States, upon the breaking out of war, would, without navy-yards and suitable docks, have to commence the building of a fleet upon Lake Ontario and another upon the upper Lakes. At the same time England, possessing a naval depot at the entrance to this system of waters, can forestall us in all our attempts both offensive and defensive."

The exact nature and extent of the system of canals constructed by England for the navigation of the Saint Lawrence River and the chain of lakes is given in an appendix to the annual report of the Canadian minister of railways and canals for the fiscal year, July 1, 1883, to June 30, 1884.

The depth of water in the canal is taken from the report, and in that report it is stated that all permanent works of the canal, such as locks, bridges, sidewalls, &c., have been built with a view to having a navigable depth of 14 feet. At present the canals have depths ample for vessels of 9-feet draught; and improvements, by which a navigable depth of 12 feet will soon be obtained, are now being made. The following table of the Saint Lawrence navigation is a table of distances from the straits of Belle Isle to the head of Lake Superior, a total distance of 2,259¾ miles, of which 71 miles are artificial navigation. The straits of Belle Isle are 1,942 sea-miles from Liverpool.

The system of Saint Lawrence navigation just described necessitates the navigation of the river along the borders of New York State, but, as stated in the quoted report of the House Military Committee for 1862, there is another system entirely within the Canadian Dominion—the Montreal, Ottawa, and Kingston route. This extends from the harbor of Montreal, passing through the Lachine Canal, the navigable sections of the lower Ottawa River, the Ottawa Canals, to the city of Ottawa, thence by the Rideau River and Rideau Canal to Kingston on Lake Ontario. Total distance, 245⅝ miles.

The following table explains the nature of this route:*

Sections of navigation.	Distance intermediate.	From Montreal.	Depth.
The Lachine Canal	.....	8½	
Lachine to Saint Anne's Lock	15	23½	
Saint Anne's Lock and Piers	½	23⅞	9 feet; 3 feet rise.
Saint Anne's Lock to Carillon Canal	27	50⅝	
The Carillon Canal	¾	51⅜	9 feet.
Carillon Canal to Chute à Blondeau	4¾	56⅛	
Chute à Blondeau Canal	½	56¼	6 feet.
Chute à Blondeau Canal to Grenville Canal	1⅝	57⅞	
The Grenville Canal	5¾	63⅝	9 feet.
Grenville Canal to entrance Rideau Navigation	56	119⅝	
Rideau Navigation ending at Kingston	126¼	245⅝	4½ feet.

"The Rideau navigation has the least depth of the system; the report does not show that it is contemplated to give this route a navigable depth for large vessels as for the Saint Lawrence route. As it is, the duty of keeping the water up to its proper level in the Rideau Navigation is very difficult, and is effected by the reserves, viz: (1) The summit level, supplied by the Lake Wolf system; (2) the eastern descending level to Ottawa, supplied by the River Tay system, discharging into Lake Rideau; (3) the southwest descending level to Kingston, supplied by the Mud Lake system, discharging into Lake Openacon. Lake Openacon receives the waters of Buck Lake and Rock Lake.

"All these waters on the descending level, supplemented by those of Lake Loughboro', flow into Cranberry Lake, which, discharging through Round Tail outlet, forms the Cataraqui River, which is rendered navigable by dams at various points, affording a line of navigation to Kingston. This navigation was closed by ice from November 27, 1883, until May 5, 1884. No delays to navigation occurred during the year. The level of the water in the several reaches was for the first time in twelve years maintained up to the close of navigation in 1883, at the full height required."

The Trent River Navigation is of little importance, in considering the Canadian frontier lines serviceable for military operations, but in a study of permanent defenses, such a route may in the future become of strategic importance, and the present state of this navigation is briefly stated for that purpose.

The term "Trent River Navigation" is applied to a series of water stretches from the mouth of the Trent on the Bay of Quinté, on Lake Ontario, to Lake Huron. This is not a connected system of navigation, and in its present condition is only efficient for local use.

* Report of Canadian Minister Railways and Canals, 1883-'84.

*"The route is from River Trent, Rice Lake, Otonabee River, and Lakes Clear, Buckhorn, Chemong, Pigeon, Sturgeon, and Camero, to Lake Balsam, the summit 166 miles from Trenton; from Lake Balsam by a canal and Talbot River to Lake Simcoe; thence by Severn River to Georgian Bay, Lake Huron, 235 miles.

"The execution of this scheme, commenced in 1837, was subsequently deferred, but certain works have been done establishing communication with the town of Lindsay and through Lake Scugog to Port Perry, 190 miles from Trenton. One hundred and fifty-five miles of this distance is navigable for light-draught vessels.

"The following table shows the distances of the reaches:

	Navigable miles.	Unnavigable miles.
From mouth of Trent River to Nine-Mile Rapids	.....	9
Nine-Mile Rapids to Percy Landing	19½	.....
Percy Landing to Heeley's Falls Dam	.....	14½
Heeley's Falls Dam to Peterborough	51¾	.....
Peterborough to Lakefield	.....	9½
Lakefield to Burleigh	12	.....
Burleigh Rapids	.....	1
Burleigh Rapids to Buckhorn Rapids	7	.....
Buckhorn Rapids	.....	1
Buckhorn Dam to Lindsay	36¼	.....
Lindsay to Port Perry, Lake Scugog	28¾	.....
	155¼	34¾

"In connection with this scheme, the Murray Canal is being constructed across the Isthmus of Murray, connecting the headwaters of the Bay of Quinté and Lake Ontario. This cut is 4⅛ miles long, and the canal will have a depth of 11 feet below the lowest known water-level of the lake, and a width at the bottom of 80 feet. There are no locks."

The remaining system of navigation to be considered, with reference to the frontier strategic lines of communication, is that of the Richelieu and Lake Champlain.

*"This system commences at Sorel, at the confluence of the Saint Lawrence and Richelieu Rivers, 46 miles below Montreal. It extends along the Richelieu River through the Saint Ours Lock to the Basin of Chambly, thence to the Chambly Canal to Saint John's and the river Richelieu to Lake Champlain."

* Report of Canadian Minister Railways and Canals, 1883-1884.

The following table shows distances, &c., to New York:

Sections of navigation.	Intermediate distances.	Total distances.	Canal depths.
Sorel to Saint Ours Lock	14	14	7 feet at low water.
Saint Ours Lock to Chambly	32	46	7 feet at low water.
Chambly Canal	12	58	7 feet at low water.
Chambly Canal to Boundary Line	23	81	
Boundary Line to Champlain Canal	111	192	
Champlain Canal to Erie Canal Junction	66	258	
Junction of Erie Canal to Albany	7	265	7 feet.
Albany to New York	146	411	

The foregoing completes the inland water lines of communication possessed by the Dominion of Canada, which, in the event of war, will facilitate the concentration of a powerful naval force to operate at places along the frontiers of New York, Pennsylvania, Ohio, and Michigan.

Beyond this to the westward England possesses no decided advantage in the navigation; and since the Sault Ste. Marie Canal is within United States territory, and the "Trent River Navigation" is, and will for years continue to be, unnavigable, the exposed points along the lake and northern boundaries will be confined to places east of Lake Huron. How, where, and to what extent the exposed points may be attacked will depend upon the Canadian railway facilities for the military resources available for such an event, after which the United States lines of communication for their available military resources will be stated.

*"THE CANADIAN FRONTIER RAILROADS.

"The Dominion of Canada had a network of railways of a total length of 9,065 miles completed at the end of June, 1883. At the same period there were 2,299 miles under construction and 3,000 miles more had been surveyed, including the work on the Canadian Pacific road. The total paid-up capital to the end of 1883 was $494,271,265, of which $111,807,069 represented Government aid."

The general details of the frontier roads, their routes, connections, and facilities for transportation of troops and war material for hostile operations on the United States frontier, are as follows for the different roads:

†"THE INTERCOLONIAL RAILROAD.

"From Halifax to Quebec along the coast of New Brunswick, Gulf of Saint Lawrence, with numerous branches up the Saint Lawrence River at Rimouski, and thence along the right (south) bank of the Saint Lawrence River to Levis Point opposite Quebec. This road with its extensions is operated and maintained by the Government. The total length of direct mail line, Quebec to Halifax, is 688 miles."

* Statesman's Year Book, 1885, page 559.

† Report of Canadian Minister on Railways and Canals, 1883-'84.

*Intercolonial Railway connections.**

Miles.	Stations.	Connections.
.....	Halifax	Allan Royal Mail Steamship Company, fortnightly to Liverpool, 2,480 miles.
9	Windsor Junction	Windsor and Annapolis Railroad. At Annapolis, tri-weekly steamers to Digby and Saint John, New Brunswick. Digby, railroad to Yarmouth; steamers to Halifax.
62	Truro	Pictou Branch to Pictou, 52 miles. At New Glasgow this road connects with Halifax and Cape Breton Island Railroad to Port Mulgrave on Strait of Canso, 80 miles from Halifax.
122	Spring Hill	Spring Hill Railroad to Parrsborough, Bay of Fundy.
180	Painsec Junction	Point du Chene Branch eastward.
188	Moncton	Branch to Saint John, New Brunswick. Branches on this road at Salisbury to Hopewell and Hampton to Saint Martin's, both on Bay of Fundy. Distance from Moncton to Saint John 89 miles.
234	Kent Junction	North Shore Railroad to port of Richibucto, Gulf of Saint Lawrence.
250	Chatham Junction	Railway to Chatham, Miramichi Bay. A road has been subsidized to run westward through New Brunswick to Fredericton, 40 miles, thence to Maine boundary at Vanceborough, 68 miles, on the Saint John Division of New Brunswick Railroad. $128,000 subsidy. This will connect Vanceborough direct with Miramichi Bay. Total distance, 108 miles.
310	Bathurst	The Caraquette Railroad Company has been subsidized $192,000, May 6, 1884, to build road from Bathurst to Shippegan Harbor. No work done yet.
373	Campbellton	Stage lines daily to points along Chaleur Bay to Gaspé.
386	Metapediac	Subsidized Baie des Chaleurs Railroad to Paspebiac. No work done yet.
496	Rimouski	In season, weekly, Allan Line Royal Mail steamer to Liverpool.
562	Rivière du Loup	A subsidy of $240,000 voted to build branch to Edmundston, the terminus of New Brunswick Railroad.
678	Point Levis	Opposite Quebec. Grand Trunk Railroad Junction.

The rolling stock of the Intercolonial Railroad.†

	Locomotives.	First-class passenger.	Second-class passenger.	Postal and smoking.	Baggage and express.	Vans.	Box.	Cattle.	Platform (10, 15, 20 tons).	Hoppers (5 tons).	Gondola (20 tons).	Total.	Snow plows.	Wing plows.	Flangers.	Total.
Condemned June 30, 1884	.....	.....	.....	.....	1	3	1	3	2	.....	1	11	.....	.....	.....	.....
Serviceable and repairing	163	68	75	17	29	48	1,456	69	1,439	595	782	4,758	30	10	20	60
Total on hand June 30, 1884	163	68	75	17	30	51	1,457	72	1,441	595	783	4,769	.....	.....	.....	.....

‡"This road is the property of the Dominion Government, and the cost of the road was $41,176,654.19, including equipment, to 1883. The road is laid with steel rails, 56 to 67 pounds; 2,640 ties are used to the mile. The heaviest grade is 65 feet per mile, and shortest curve 694 feet radius. Passenger trains average 25 miles per hour and freight trains 15 miles her hour.

"THE NEW BRUNSWICK RAILROAD.

"This is a private corporation. Its president is Mr. S. Thorn, of 67 Wall street, New York City. It operates the New Brunswick and Canada Railway. The combined capital is $5,679,500, with subsidies of $76,000 to New Brunswick Railway and $575,000 to New Brunswick and Canada Railway. The latter also has a floating capital of $200,000. It also operates the Fredericton Railway, 22.5 miles long. The capital is $628,200, and Government subsidies amount to $230,000." The following are details.§

* Compiled from the Travelers' Official Guide, May, 1885, and Report of Canadian Minister Railways and Canals.
† Report of Canadian Minister Railways and Canals, 1883–'84.
‡ Foreign Railways of the World, Vol. I.
§ Compiled from Official Report Canadian Minister on Railways and Canals, and Travelers' Guide, May, 1885.

Miles.	Stations.	Connections.
.....	Saint John, New Brunswick.	Intercolonial Railroad. Steamers to Annapolis and Yarmouth, Nova Scotia, in summer.
46	Fredericton Junction	With Fredericton branch. Main line runs to the westward.
85	McAdam	Junction with Northern and Southern Division.
91.5	Vanceborough	Maine Central
	THE NORTHERN AND SOUTHERN DIVISION.	
.....	Saint Andrews	Frontier Steamship Company.
28	Watt Junction	Branch to Saint Stephen (where connects Frontier Steamship Company), also to Calais and Princeton, Me.
43	McAdam	With Saint John Division. East and West.
83	Debec Junction	North and South Division continues to Houlton, 7 miles.
94	Woodstock	Junction with line from Saint John from Fredericton Junction to Fredericton, 22.50 miles; Fredericton to Woodstock, 63 miles; Woodstock to Saint John, 134.50 miles.
149	Aroostook	Junction to Presqu' Isle, Me., 34 miles.
207	Edmundston	As stated in the table for the Intercolonial Railroad, a subsidy of $240,000 has been voted by Dominion Parliament to connect Edmundston by road to Rivière du Loup.

"A connection from Fredericton Junction to the Intercolonial road at Chatham is in course of construction, subsidized to $128,000. This will connect Maine frontier with Gulf of Saint Lawrence. Distance, 108 miles.

"The New Brunswick Railway has 84 miles of 56 and 45 pound iron rails, and 217 miles of 56 pound steel rails; 2,113 ties to the mile; the Fredericton road 56-pound iron rails; 2,300 ties to the mile. The heaviest grade is 80 feet per mile and sharpest curve 540 feet radius.

*"The rolling stock of the combined roads is: 20 locomotives, 22 passenger, 2 baggage and express, and 411 freight cars.

"The Fredericton Railroad has besides, 5 locomotives, 2 passenger, and 16 freight cars.

"THE GRAND TRUNK RAILWAY.

"This is the largest system under one management in Canada. Its paid up capital amounts to $230,605,956.24. The Government bonus has amounted to $755,906.08, together with a loan of $15,142,633.33 by the Dominion Government. The cost of the main line and Buffalo and Lake Huron Branch, including the rolling stock, was $220,688,439.89. Main line, Grand Trunk Division, 887 miles; Buffalo and Lake Huron, 162; Montreal and Champlain Junction, 27.25; Georgian Bay and Lake Erie, 171."

The total length of the Grand Trunk Division is 1,247¼ miles. The total length of the Great Western Division is 823.67 miles. The following is a table of distances and connections:†

Miles.	Stations.	Connections.
.....	Montreal	With diverging roads. Saint Lawrence Royal Mail steamers.
76	Richmond	The main line then goes to Coaticook, on the boundary, 175 miles by the Grand Trunk Railway from Portland, and 122 miles from Montreal.
108	Arthabaska	Arthabaska and Three Rivers Branch.
172	Point Levis	Opposite Quebec.

* Foreign Railways of the World, Vol. I, page 27.
† Travelers' Official Guide, May 1885.

The main line from Richmond to Portland, Me, is in connection at the following points in Quebec province:

Miles.	Stations.	Connections.
101	Sherbrooke	Passumpsic Railroad. Lake Memphremagog and to Boston.
104	Lennoxville	International Railway to Quebec boundary. This road is 69¾ miles long. The railroad company has 2 locomotives, 2 passenger, 1 baggage, and 30 freight cars.
	SOUTH AND WESTWARD—CHAMPLAIN DIVISION.	
.....	Montreal	
7	Saint Lambert	A branch described below to Fort Covington.
27	Saint John's	Central Vermont and Delaware and Hudson Canal Companies' Railroads.
50	Rouse's Point	Western Division Central Vermont Railroad. Ogdensburg and Lake Champlain Railroad.
7	Saint Lambert	
24	Saint Isidore	Road branch to Fort Covington, 74 miles from Montreal.
51	Mooer's Junction	Delaware and Hudson Canal Company's Railroad and the Ogdensburg and Lake Champlain Railroad.
	ROAD ON LEFT BANK OF SAINT LAWRENCE RIVER AND THE LAKES.	
.....	Montreal	
37	Coteau	Canada Atlantic Railroad to Ottawa.
112	Prescott	Saint Lawrence and Ottawa Railroad and ferry to Ogdensburg.
125	Brockville	With Canadian Pacific Railroad.
163	Kingston	Kingston and Pembroke Railroad and the Rideau River Navigation.
203	Deseronto Junction	Bay of Quinté Railroad.
220	Bellville	
232	Trenton	"Trent River Navigation" and Trenton-Picton Railroad.
264	Cobourg	Cobourg, Peterborough and Marmora Railroad.
270	Port Hope	Junction of main line and Midland Division, which runs up to Midland, head of Georgian Bay.
303	Whitby	Another junction with Midland Division.
322	Scarborough Junction	Another junction with Midland Division.
333	Toronto	With Northern Railway of Canada for Collingwood, &c.; with Hamilton Division for Hamilton, Niagara Falls, &c.; with steamers on Lake Ontario.

*Continuation of Grand Trunk Railroad and connections.**

	ACROSS WEST CANADA.	
Miles.	Station.	Connections.
233	Toronto	
281	Guelph	Junction with Wellington and Grey and Bruce Divisions.
321	Stratford	Junction Buffalo and Toronto Division.
		Junction with Georgian Bay and Lake Erie Division. These branch roads connect with roads terminating at ports on Lake Huron, viz, Goderich-Kincardine, Southampton, and Wiarton.
331	Saint Mary's	Road to London, 32 miles branch.
401	Point Edward	Canadian terminus. Connection with Grand Trunk line of steamers for Mackinaw and all points on Lakes Huron and Michigan.
	ALONG LAKE SHORE.	
233	Toronto	
282	Hamilton	Road to Buffalo via Suspension Bridge, 44 miles.
300.5	Harrisburg	Junction Great Western Division with Wellington, Grey and Bruce, and Brantford Divisions.
310.5	Paris	Junction Main Line and Great Western Division.
329.5	Woodstock	Junction Main Line and Great Western Division.
348	London	Junction Main Line and Great Western Division.
378.5	Glencoe	Junction Main Line and Loop Line. The Loop Line, Glencoe to Buffalo, 158 miles, connects at Saint Thomas with road from Port Stanley, at Simcoe with road to Port Dover, Canfield with road to Port Colbourne and Fort Erie, all on the northern shore of Lake Erie.
458	Windsor	Ferry to Detroit. Connections thence with roads in the United States.

* Travelers' Guide, 1885.

*"The Grand Trunk Railway track has 191 miles laid with 65-pound iron rails, and the remainder has 66-pound steel rails. Two thousand six hundred and forty ties are laid per mile. The greatest grade is 81 feet per mile, and the sharpest curve is 1,495 feet radius. The rolling stock consists of 592 locomotives, 285 first-class passenger, 176 second-class passenger, 121 baggage, mail, and express, 12,556 box and stock, and 3,601 flat cars. The road capacity is illustrated by statistics. Four million five hundred and sixty-three thousand one hundred and forty-nine passengers and 5,522,502 tons of freight were carried in 1882–'83."

"THE CANADIAN PACIFIC RAILROAD.

"Main line, Montreal to Port Moody, Pacific coast, 2,893 miles. Main line in operation, Montreal to end of track, 534 miles. Nipigon to Saint Stephen (Rocky Mountain summit), 1,459 miles, total 1,993 miles." From the last annual report at meeting at Montreal, June 13, 1885, the track is expected to be finished by the end of September, 1885, there being only 203 miles in British Columbia yet to finish. The terminus of the road is at Port Moody, in English Bay, an arm of the Strait of Georgia.

†"The total distance between the terminal points, Port Moody and Callendar, by the route via Winnipeg and Kicking Horse Pass, is 2,550 miles, the four sections of which are (1) Callander to Port Arthur, 657 miles, completed by Canadian Pacific Railroad Company; (2) Port Arthur to Red River, 428 miles, commenced by Canadian Government and completed by Canadian Pacific Railroad Company; (3) Red River to Savona's Ferry, 1,252 miles, being built by Canadian Pacific Railroad Company; (4) Savona's Ferry to Port Moody, 213 miles, built by Government."

Canadian Pacific Railroad connections and branches.‡

Miles.	Stations.	Connections.
	Montreal	
120	Ottawa	Saint Lawrence and Ottawa Railroad to Prescott, 54 miles (opposite Ogdensburg).
149	Carleton Junction	Main line thence goes to Sudbury Junction, where it branches to Algoma Mills, where the lake steamers connect with Lake Huron and Michigan ports. The main line of the Canadian Pacific Railroad runs direct to Jack Fish Bay, Lake Superior, and along the northern shores of that lake to Port Arthur.
168	Smith Falls	Branch to Brockville, 54 miles (opposite Plattsburg, N. Y.).
379	Toronto Junction	Branch to Teeswater, 74 miles west of Toronto. Branch to Owen Sound (120 miles from Toronto), where steamer lines run to Port Arthur, belonging to Canadian Pacific Railroad Company. There are branch roads and extension from Toronto to London and Saint Thomas, where connections are made with other roads.
1,000	Port Arthur	Canadian Pacific steamers on the lakes.
1,429	Winnipeg	Pembina Mountain section to Gretna, 70 miles, on the United States boundary; and to Manitou, 102 miles from Winnipeg; Emerson Section to Emerson, 66 miles on United States boundary; Manitoba Southwestern Colonization Railroad, 51 miles to end of track; Stonewall Section, 20 miles northwest of Winnipeg; East Selkirk branch, 20 miles north of Winnipeg.
1,485	Portage la Prairie	Manitoba and Northwestern Railroad to Minnedosa, 78.5 miles. This branch runs up to the Saskatchewan region.
1,827	Moose Jaw	
2,392	Kicking Horse Pass	Summit, 5,296 feet.
2,683	Savona's Ferry	
2,895	Port Moody	English Bay, Strait of Georgia, North Pacific coast.

* Foreign Railroads of the World, Vol. I, p. 27.

† Report of Canadian Minister on Railways and Canals, 1883–'84.

‡ Travelers' Guide, May, 1885, and Report of Canadian Minister on Railways and Canals, 1883–'84.

Saint Albans: Missisquoi Railroad to Richford and connections; Central Vermont Railroad from New London and points in United States to Montreal, via Montreal and Vermont Junction, via Saint Armand, via Canada Atlantic Railroad to Coteau, via Rouse's Point, and to Ogdensburg, via Ogdensburg and Lake Champlain Railroad, via Rouse's Point to Saint John's, &c.; Grand Trunk Railroad; Richelieu River and Lake Champlain Navigation, via Chambly Canal, from Sorel, on Saint Lawrence River.

Rouse's Point: Near the boundary at head of Lake Champlain, and therefore in connection with all the roads as stated for Saint Albans, Vt.

Mooer's Junction: Champlain Division of Grand Trunk Railroad to Montreal; Delaware and Hudson Canal Company's Railroad; and the Ogdensburg and Lake Champlain Railroad.

Fort Covington: On the Saint Lawrence River at the New York boundary line opposite Dundee. Grand Trunk Railroad has branch to Montreal from Dundee, 74 miles.

Ogdensburg: On the Saint Lawrence opposite Prescott, which is on the Grand Trunk Railroad; and Ottawa and Saint Lawrence Railroad. Ogdensburg is a city of 10,000 inhabitants, and ferry-boats ply to Prescott. Ogdensburg and Lake Champlain Railroad; Rome, Watertown and Ogdensburg Railroad, which skirts the shores of Lake Ontario to Niagara; the Utica and Black River Railroad terminates at Ogdensburg; the Saint Lawrence River Navigation, also, at Ogdensburg.

Morristown: On the Utica and Black River Railroad; on the Saint Lawrence, opposite Brockville; a branch of Canadian Pacific Railroad terminates at Brockville.

Clayton: Clayton and Theresa Branch of the Utica and Black River Railroad. Situated on Saint Lawrence River near Thousand Islands.

Cape Vincent: On the Saint Lawrence River where it issues from Lake Ontario, 12 miles southeast of Kingston; Kingston being on Grand Trunk Railroad. Kingston and Pembroke Railroad, and the Rideau Navigation outlet to Lake Ontario; steam ferry plies from Ogdensburg to Cape Vincent; Rome, Watertown and Ogdensburg Railroad has branch to Cape Vincent.

Sackett's Harbor: Site of Madison Barracks. Utica and Black River Railroad has branch passing through Watertown, N. Y.

Oswego: A city of 23,000 inhabitants on the southeastern shore of Lake Ontario, at the mouth of the Oswego River. Harbor defended by Fort Ontario. It is the northern terminus of the Oswego Canal, which connects at Syracuse with the Erie Canal. The railroads which converge at Oswego are: The New York, Ontario and Western Railroad; Rome, Watertown and Ogdensburg Railroad; Lake Ontario Shore Railroad; and the Oswego and Syracuse Railroad. The steamers of Canadian Navigation Company ply between this place and Montreal. There are other lines of steamers plying on the lake to Oswego.

Fairhaven: A village on Little Sodus Bay, 12 miles southwest of Oswego. A coaling depot of Pennsylvania coal, terminus of the Northern Central Railroad from Oswego, Sayre, and Wilkes-Barre, Pa. It is 3 miles from Sterling, on the Rome, Watertown and Ogdensburg Railroad, and 12 miles from Weedsport, on the New York Central and Hudson River Railroad, and New York, West Shore and Buffalo Railroad.

Sodus: A town on Sodus Bay, 41 miles west-southwest of Oswego and 30 miles east by north from Rochester. It is on the Rome and Ogdensburg Railroad, and the terminus of the Sodus Bay Division of the Northern Central Railroad. It has a good harbor.

Charlotte: The lake port of Rochester at the mouth of the Genesee River, on a branch of the New York Central Railroad, 7 miles north of Rochester. The Rome, Watertown and Ogdensburg Railroad also passes through the town. Population, 1,500. It has several shipyards and grain elevators. The lake steamers touch here daily—Toronto, Port Hope, and Kingston and Montreal.

Rochester: A large manufacturing city of about 100,000 inhabitants. The Erie Canal crosses the Genesee River at this place. It is in railroad communication with all parts of the Union by the following roads: New York Central and Hudson River Railroad, New York, West Shore and Buffalo Railroad, Northern Central Railroad, Delaware, Lackawanna and Western Railroad, Rochester and Pittsburgh Railroad, and connections at Charlotte.

Lockport: A city of 25,000 inhabitants, is the site where a system of locks brings the Erie Canal to the level of the Genesee. It is situated on the New York Central and Hudson River Railroad, 25 miles north-northeast of Buffalo; railroad to Niagara Falls. The Erie Railroad has branch from Suspension Bridge to Lockport.

Lewiston: On the Niagara River at the head of navigation, 7 miles below the cataract, and 7 miles from Lake Ontario. Steamers ply daily between Toronto and Lewiston. It is opposite Queenstown in Canada, and a branch of the Canada Southern Railroad runs to Niagara on the Canadian side. The Rome, Watertown and Ogdensburg Railroad terminates here. Railroad to Suspension Bridge and connections to all points.

Youngstown: At the mouth of the Niagara River, has a good harbor formed by the mouth of the river; steamers touch from Toronto. It is 1 mile from Fort Niagara, which commands the river.

Suspension Bridge, or Niagara City: The site of the railroad suspension bridge over the Niagara River, 800 feet long and 240 feet above the river. The bridge has two floors, upper one for railroad and the lower one for carriages. The New York Central and Hudson River Railroad has a branch which connects with Grand Trunk Railroad, and the Erie Railroad also connects with Canadian railroads.

Niagara Falls: On the New York Central and Hudson River Railroad and Erie Railroad branch. The cantilever bridge of Michigan Central Railroad crosses here, and there is a carriage suspension bridge to Clifton on Canadian side.

Tonawanda: On the Niagara River, at the mouth of Tonawanda Creek, 11 miles north of Buffalo. Population, 2,812. It is on the Erie Canal and several branches of the Erie Railroad and New York Central and Hudson River Railroad. Connection, Michigan Central Railroad.

International Bridge: Crosses the Niagara 6 miles below Buffalo Junction with the Erie Railroad and Canada Southern and Grand Trunk Railroad on Canada side.

Buffalo: A city of 150,000 inhabitants, at the eastern extremity of Lake Erie. It has a water front of 5 miles, 2½ on the lake and 2½ on the Niagara River. A commercial city and a leading manufacturing city. It is the terminus of the Erie Canal and of several railroad lines. In iron and steel manufactures Buffalo ranks next to Pittsburgh, the products of which amounted to about $7,000,000 in 1880; 612,976 tons of coal were distributed from Buffalo in 1879. The following are the railroad communications, viz: Buffalo, New York and Philadelphia Railroad to Pittsburgh, Delaware, Lackawanna and Western Railroad, Erie Railroad, Grand Trunk Railroad, Lake Shore and Michigan Southern Railroad, Michigan Central Railroad, New York Central and Hudson River Railroad, New York, Chicago and Saint Louis Railroad, New York, West Shore and Buffalo Railroad, Rochester and Pittsburgh Railroad.

Irving: A post town on Cattaraugus Creek, ½ mile from Lake Erie, on Lake Shore Railroad, 29 miles south-southwest of Buffalo.

Dunkirk: A port of entry; safe and commodious harbor and wharves for lake steamers. Population, 7,000. Extensive workshops of Erie Railroad. Is 40 miles south-southwest of Buffalo. On Erie Railroad, Buffalo, New York and Philadelphia Railroad, Lake Shore and Michigan Southern Railroad, Dunkirk, Allegheny Valley and Pittsburgh Railroad, New York, Chicago and Saint Louis Railroad.

Brocton: Same road as for Dunkirk. It is near Lake Erie, about 9 miles southwest of Dunkirk. Population, 500.

Westfield: One mile from Lake Erie, 17 miles southwest of Dunkirk. Population, 3,000. A manufacturing town. On the Lake Shore and Michigan Southern Railroad, and the New York, Chicago and Saint Louis Railroad.

Erie, Pa.: A city of 25,000 inhabitants, on Lake Erie. It has a safe land-locked harbor 4 miles long by 1 mile wide, protected by Presque Isle. Large steamboats ply between this place and other lake ports. A very important manufacturing city. Lake Shore and Michigan Southern Railroad, Erie and Pittsburgh Railroad, New York, Chicago and Saint Louis Railroad, Philadelphia and Erie Division of Pennsylvania Railroad. The usual winter quarters of the United States naval vessel "*Michigan*," on the lakes.

Girard: A post town; 704 inhabitants; about 2 miles from Lake Erie; 15 miles west-southwest of Erie City. On Lake Shore and Michigan Southern Railroad, Erie and Pittsburgh Railroad, and New York, Chicago and Saint Louis Railroad.

Conneaut: A town in Ohio of 1,173 inhabitants; 2 miles from Lake Erie, 27 miles west-southwest of Erie. On Lake Shore and Michigan Southern Railroad, and New York, Chicago and Saint Louis Railroad. It has a good harbor.

Ashtabula: A manufacturing town of 2,000 inhabitants, on the Ashtabula River, which empties into Lake Erie at harbor, 3 miles north of Ashtabula. It is on Lake Shore and Michigan Southern Railroad, New York, Chicago and Saint Louis Railroad, and Ashtabula and Pittsburgh Railroad.

Painesville, Ohio: A post village and manufacturing town of 3,729 inhabitants. On the Grand River. It is 3 miles from Lake Erie and 66 miles west-southwest of Erie. It is on Lake Shore and Michigan Southern Railroad, and New York, Chicago and Saint Louis Railroad. It is the northern terminus of the Painesville and Youngstown Railroad. The railroad bridges cross the Grand River.

Fairport: The Lake Erie port of Painesville. Painesville and Youngstown Railroad.

Willoughby: A small town of 900 population. On the Chagrin River near Lake Erie. Lake Shore and Michigan Southern Railroad, New York, Chicago and Saint Louis Railroad. Eighteen miles northeast of Cleveland.

Cleveland: A city of about 160,000 inhabitants; situated on the south shore of Lake Erie at the mouth of the Cuyahoga River, which flows through the city and affords a fine sheltered harbor, with a commodious ship channel 200 feet wide, extending 1,200 feet into the lake. A harbor of refuge is being constructed by the United States Government to cost $1,800,000. Cleveland is connected with the Ohio River by canal to Portsmouth, and is the center of railroads branching out in all directions: Lake Shore and Michigan Southern Railroad, New York, Chicago and Saint Louis Railroad, Cleveland, Columbus, Cincinnati and Indianapolis Railroad, Cleveland and Pittsburgh Railroad, Connotton Valley Railroad, New York, Pennsylvania and Ohio Railroad, and Valley Railroad. The resources of the city by its manufactories and industries are immense.

Black River, or Lorain: A town of 838 inhabitants; on Lake Erie, at mouth of the Black River. Lorain is the terminus of Cleveland, Lorain and Wheeling Railroad, 26 miles west of Cleveland. It has a good harbor, machine-shops, railroad works, &c. At Elyria, 8 miles due south, it connects with Lake Shore and Michigan Southern Railroad.

Vermillion: A village and shipping port on Lake Erie; 40 miles west of Cleveland and 20 miles east of Sandusky. Machine-shops and ship-yard. On Lake Shore and Michigan Southern Railroad. At the mouth of the Vermillion River.

Huron: On Lake Erie, at mouth of Huron River. A small town 9 miles east-southeast of Sandusky. A good harbor, with a canal to Milan for vessels of 250 tons. Milan is 8 miles south of Huron. Lake Shore and Michigan Southern Railroad. Terminus of Lake Erie and Wheeling Railroad.

Sandusky: A city of 13,000 inhabitants, on Sandusky Bay, which is 15 miles long by 5 miles wide, and forms an excellent harbor. It is an important shipping point, and in the season the wharves are lined with steamers. There are numerous industries, machine-shops, ship-yard, &c. Lake Shore and Michigan Southern Railroad, Baltimore and Ohio Railroad, Lake Erie and Western Railroad, Indiana, Bloomington and Western Railroad.

Sandusky: There are a number of small islands off the Bay of Sandusky; Kelly's Island, Put-in-Bay Island, Bass Island, and West Sister; while Point au Pelee belongs to Canada. These islands are settled and have extensive vineyards, so that they are known as the Wine Islands. They would be of strategic importance in case of war..

Port Clinton: A town of 543 inhabitants; on Lake Erie, at mouth of Portage River, 15 miles west-northwest of Sandusky. It has a good harbor, saw-mills, &c. On Lake Shore and Michigan Southern Railroad.

Oak Harbor: On Portage River, 11 miles west of Port Clinton. Small town. Lake Shore and Michigan Southern Railroad.

Maumee Bay: Mouth of Maumee River, on Lake Erie. Maumee City, or South Toledo, 9 or 10 miles south of Toledo, is the head of navigation for the steamboats. Canal to Fort Wayne.

Toledo: A city of 60,000 inhabitants, and situated on the Maumee River, 8 miles from Lake Erie. The bay and river afford an excellent harbor for the largest vessels. A canal, Miami and Erie Canal, connects with Cincinnati and Evansville. It is the center of thirteen different railroads, from all parts of the country. The chief industry is shipping grain, for which there are eleven large grain elevators. It has a ship-yard, boat-building establishments, and numerous manufacturing industries. The city is sufficiently far inland from the lake as not to be exposed, while its facilities for offensive purposes are good.

Monroe: On the Raisin River, 2 miles from its entrance to Lake Erie, 20 miles north-northeast of Toledo, and 35 miles south-southwest of Detroit. A ship canal connects it with Lake Erie. Manufactories of sash and blinds; two foundries, mills, &c. On Lake Shore and Michigan Southern Railroad, Flint and Pere Marquette Railroad; Toledo, Canada Southern and Detroit Railroad connects Detroit at Toledo Junction with line to Chicago.

Trenton: A post town; 1,200 inhabitants; on Detroit River. Has a ship-yard, mills, &c. On Canada Southern Railroad, Lake Shore and Michigan Southern Railroad, and Michigan Central Railroad.

Detroit: A city of 130,000 inhabitants, on the Detroit River, opposite Windsor; 18 miles from Lake Erie, and 7 miles below Lake Saint Clair. The river is here half a mile wide, deep and clear, and serves admirably for the harbor. It is the center of an extensive railway system. Seven important and some minor lines converge here. Important industries; ship-building, locomotives, machinery, iron bridges, &c., and it has other important trade in grain and lumber. Detroit, Grand Haven and Milwaukee Railroad, Detroit, Lansing and Northern Railroad, Grand Trunk Railroad (Canada), Great Western of Canada Railroad, Lake Shore and Michigan Southern Railroad, Michigan Central Railroad, Wabash, Saint Louis and Pacific Railroad.

Lake Saint Clair: Thirty miles long, and 24 miles greatest breadth; the average breadth is 12 miles; depth 20 feet. The shoals in the northern part are traversed by a deep canal bordered by dikes constructed by the United States Government.

Saint Clair River: Saint Clair River brings the waters of Lake Huron into Lake Saint Clair. The river runs southward for 44 miles. It is nearly a mile wide, and navigable by large steamboats. The chief towns on its banks are Port Huron and Sarnia. The Canadian shore is skirted between Windsor and Sarnia by the Great Western Division of the Grand Trunk Railway along the southern shore of Lake Saint Clair, and by the Erie and Huron Railroad from Rondeau, on Lake Erie, to the mouth of the Saint Clair River at the head of the lake, opposite to Port Lambton, Mich.; the railroad then goes along the left bank of the river (Canada side) to Sarnia. On the American side Port Huron is connected to Detroit by the Grand Trunk Railroad.

Port Huron: A city of Michigan of about 10,000 inhabitants. A port of entry on Saint Clair River where it issues from Lake Huron, 62 miles north-northeast of Detroit. It is at the mouth of Black River, and large quantities of pine timber are brought there. Steam ferry-boats to Sarnia, and in season daily steamers to Detroit. Ship-yards, saw-mills, machine-shops, grain elevators, and other industries. The Grand Trunk Railroad Branches, and Port Huron and Northwestern Railroad.

Lexington: A post village and port of entry on Lake Huron, 20 miles north of Port Huron. Steamer to Detroit daily in summer. Population, 1,200. But few industries. No railroads.

Sanilac: A small town on the lake, about 10 miles north of Lexington.

Forester: A town on Lake Huron, 40 miles north of Port Huron. Population, 250.

Sand Beach: A post village on Lake Huron, 62 miles north of Port Huron. A harbor of refuge, with pier and breakwater. Saw-mills, lumber. Population, 350. Terminus of Sand Beach Division of the Port Huron and Northwestern Railroad.

Huron City: On Lake Huron, near the head of peninsula. A small town of Huron township. Lumber district. Stage road to Sand Beach.

Port Austin: On Lake Huron, at the mouth of Saginaw Bay, about 20 miles west of Huron City, 87 miles from Port Huron; the terminus of Port Austin Division of Port Huron and Northwestern Railroad. Population, 905.

Saginaw Bay: Of Lake Huron, the largest body of water which indents the southern peninsula of Michigan; 60 miles long and 30 miles greatest breadth, and affords good navigation and safe harbors. The towns on the east shore are—

Caseville: A post village; 1,042 population; good harbor. Blast furnace, salt works, and lumber depot. Terminus of Pontiac, Oxford and Port Austin Railroad.

Bay Port: On Saginaw Bay, 46 miles from East Saginaw. Saginaw, Tuscola and Huron Railroad.

Bay City: On the east bank of the Saginaw River, about 5 miles from Saginaw Bay. It is on the Flint and Pere Marquette Railroad, and branches of the Michigan Central Railroad. Population, 15,000. Three bridges over the river. The Saginaw River is 30 miles long. Steamboats ascend it as far as Saginaw.

Saginaw: A city of 10,000 inhabitants, 20 miles southwest of Bay City, 2 miles southwest of East Saginaw. Three bridges. Vessels drawing 10 feet of water ascend to this point. Extensive manufactories; salt and lumber. Flint and Pere Marquette Railroad; Michigan Central Railroad; Detroit, Lansing and Northern Railroad; and at Saginaw Junction, Port Huron and Northwestern Railroad.

East Saginaw: Is the most populous of these towns; it is only 2 miles from Saginaw, and has 17,000 inhabitants; it is on the railroads mentioned and is a more important place. The three places may be considered as one large commercial center; the chief place or port of entry of Saginaw Bay.

Tawas City: A post village on the northwest shore of Saginaw Bay, at the mouth. It is the best natural harbor of refuge on the west side of Lake Huron. Population, 700. On the Detroit, Bay City and Alpena Railroad; branch Michigan Central Railroad.

Au Sable: A town on west coast of Lake Huron, at the mouth of the Au Sable River. It is 65 miles north-northeast of Bay City, and contiguous to town of Oscoda. Population, 1,200. It is the terminus of Detroit, Bay City and Alpena Railroad. Stages run thence along the shore to coast towns of Greenbush, Harrisville, Alcona, Ossineke, and Alpena.

Alpena: A post town of 4,000 inhabitants, on Thunder Bay, at the mouth of Thunder River. A shipping port. It has 2 foundries, 2 planing-mills, 3 shingle-mills, and 10 saw-mills. No railroad communication except by stage to Au Sable.

Rogers City: A post village, 130 miles north of Bay City, on Lake Huron. Population, 600. No railroad. Machine-shop and saw-mill. Lumber and firewood for steamboats.

Cheboygan: A town of 2,000 inhabitants, at the mouth of the Cheboygan River, near northern extremity of Michigan, opposite the Straits of Mackinaw; 16 miles from Mackinaw City, on the Mackinaw Division of Michigan Central Railroad. Has a foundry and 6 saw-mills.

Mackinaw City: A town on the Straits of Mackinaw, with a good harbor. It is the terminus of Michigan Central and Grand Rapids and Indiana Railroads. The Strait of Mackinaw is 4 miles wide, and is the channel for the commerce of Lake Michigan through to the other lakes.

Mackinac: A small island in the strait, the site of Fort Mackinac, on a rocky hill 200 feet high. Chiefly a summer resort. Population, 200. The Star Line of steamers to Toledo, Detroit, and Port Huron.

Point Saint Ignace: On the opposite or northwest shore of Strait of Mackinaw, the terminus of the Detroit, Mackinac and Marquette Railroad and Marquette and Western Railroad. The Marquette Transportation Company's boats ferry across the Strait of Mackinaw to connect with the Michigan Central, and Grand Rapids and Indiana Railroads. Saint Mary's Strait or River is the outlet of Lake Superior to Lake Huron, and forms part of the United States boundary. It is 60 miles long, and enters Lake Huron by several channels. Its navigation was obstructed by the rapids of Sault Ste. Marie, a fall of 20 feet in one mile. This is overcome by the Sault Ste. Marie Canal, on the Michigan side, one mile long. The shores of Lake Superior are but sparsely settled, and the navigation of the lake is controlled by the Sault Ste. Marie Canal. The Canadian shore is skirted by the Canadian Pacific Railroad, passing the ports of Nipigon and Port Arthur. Detroit, Mackinac and Marquette

Point Saint Ignace—Continued.

Railroad traverses the peninsula between Lakes Superior and Michigan. The Chicago and Northwestern road has termini at Marquette, L'Anse, and Ontonagon, on Lake Superior, and also at Duluth and Ashland. The Chicago, Saint Paul, Minneapolis and Omaha Railroad and the Wisconsin Central Railroad have termini at Ashland.

Duluth: The eastern terminus of the Northern Pacific Railroad, at the mouth of the Saint Louis River, which empties into Fond du Lac, the western end of Lake Superior. Duluth has 3,000 population, and is a growing place. Foundries, machine-shops, and workshops of the railroad. A port of entry, and a large grain-shipping port. The harbor has been greatly improved by the United States Government by dredging and construction of breakwaters and piers.

The above list and brief descriptions of the frontier and lake shore towns and their railroad connections serve to point out the exposed places along the Canadian frontier. To the westward of Lake Superior the boundary is not so sharply defined by natural barriers; a watershed exists in general along the boundary line; but the resources of the United States along the northern frontier are, owing to its much milder climate and more densely populated country, so much greater than that of the Dominion of Canada that nothing more need be said about that portion of the frontier.

*"The available shipping and sum total of the railroad transportation capacity of Canada and the United States will next be considered in this connection, and from these statistics the points best available for each country to establish a base for hostile operations be deduced.

Navigation and shipping of Canada.

	Vessels.	Tons.	No. of crew.
Sea-going vessels.			
Entered	11,160	969,904	159,063
Cleared	11,183	1,432,865	156,392
Total	22,343	2,402,769	315,455
Average	11,172	1,201,384	157,728
Nationalities of sea-going vessels.			
British	3,327	1,181,931	95,067
Canadian	11,796	715,418	83,675
Foreign	7,220	505,420	136,713
Total	22,343	2,402,769	315,455
United States sea-going vessels trading with Canada.			
Arrived	2,769	1,124,508	57,295
Departed	2,658	1,115,068	55,047
Total	5,427	2,239,574	112,342
Inland navigation between United States and Canada (exclusive of ferriage).			
Arrived	16,768	1,340,309	136,545
Departed	16,045	490,300	124,724
Total	32,813	1,830,609	261,269
RECAPITULATION.			
Arrived, United States	6,750	585,370	43,977
Arrived, Canadian	10,016	754,939	92,568
Departed, United States	6,597	70,087	41,808
Departed, Canadian	9,448	420,213	82,916
Total	32,813	1,830,609	261,269

*U. S. Consular Report No. 50, February, 1885, page 332.

British and foreign vessels in Canadian coasting trade.

	Vessels.	Tons.	No. of crew.
Arrived, British	40,145	8,017,993	384,968
Arrived, foreign	155	96,644	3,339
Total	40,300	8,114,637	387,937
Departed, British	38,898	7,265,945	335,723
Departed, foreign	172	93,125	3,586
Total	39,070	7,359,070	339,309

Description, number, and tonnage of vessels built in Canada, year ending June 30, 1884.

Provinces.	Steamers.		Sail vessels.		Total.	
	No.	Tons.	No.	Tons.	No.	Tons.
Ontario	31	3,225	8	682	39	3,907
Quebec	10	1,318	21	2,885	31	4,203
Nova Scotia	6	118	189	34,495	195	34,613
New Brunswick	2	93	65	21,561	67	21,654
British Columbia	3	135	1	23	4	158
Prince Edward Island	1	.189	21	5,563	22	5,752
Total	53	5,078	305	65,209	358	70,287

* "For the transportation of an army corps of 36,694 men, 8,071 horses, 739 two-wheeled wagons, and 671 four-wheeled wagons, requires 71,312 register tons of shipping, so that the Canadian sea-going vessels alone are capable of transporting ten such army corps. This is deduced from a rule by a French writer allowing the following space: For each man, 1 register ton (including subsistence); for each horse, 3 register tons (including forage); for each two-wheeled wagon, 5 register tons; for each four-wheeled wagon, 10 register tons; for each bridge wagon, 15 register tons."

The transportation capacity of the British merchant marine is in so great excess of available troops that details need not be given.

The statistics of Canadian vessels engaged in the inland trade between the United States and Canada show an aggregate of 10,000 vessels of 600,000 tons, whose transportation capacity would be sufficient for ten army corps such as previously mentioned; the 600,000 tons of inland navigation being equal to, if not greater in the capacity for carrying troops, that of 700,000 tons of sea-going vessels, chiefly on account of the shorter time which they would have to carry supplies for the troops transported.

The centers of the shipping and railroad communications of Canada are thus seen to be at Halifax and Saint John, New Brunswick; Quebec, more especially when the proposed bridge over the Saint Lawrence is completed; Montreal, Kingston, Toronto, Welland Canal, Windsor, and Sarnia.

The following vessels of the English navy are available for service on the lakes. These are divided into three groups according to their draught: first, those with less than 12 feet and over 9; second, those having less than 9 and over 7 feet draught; and third, those with less than 7 feet draught.

* Reg. No. 3566. Translation from Mittheilungen aus dem Gebiete des Seewesens, April, 1885.

ARMORED VESSELS.

	Name.	Hull, material.	Displacement.	Draught.	Battery.
			Tons.	′ ″	
1	Viper*	Iron	1,230	11 8	Two 7″ M. L. R. and two howitzers.
2	Vixen*	do	1,230	11 10	Do.
3	Waterwitch	do	1,280	11 11	Do.

GUN-VESSELS AND GUNBOATS.

4	Flirt	Composite	603	9 10	Two 7″ M. L. R.; two 20-pounder B. L. R.
5	Philomel	Wood	805	10 6	One 7″ M. L. R.; one 64-pounder M. L. R.
6	Bittern	do	805	10 1	One 7″ M. L. R.; two 40-pounder B. L. R.
7	Woodlark	do	805	11 0	One 7″ M. L. R.; two 64-pounder M. L. R.
8	Coquette	Composite	430	10 1	Two 64-pounder M. L. R.; two 20-pounder B. L. R.
9	Foam	do	430	10 11	Do.
10	Decoy	do	430	10 4	Do.
11	Mosquito	do	430	10 6	Two 5″ B. L. R.; two 4″ B. L. R.
12	Merlin	do	430	10 5	Two 64-pounder M. L. R.; two 20-pounder B. L. R.
13	Goshawk	do	430	10 9	Do.
14	Swinger	do	430	10 5	Do.
15	Frolic	do	610	9 6	One 7″ M. L. R.; one 64-pounder; two 20-pounder B. L. R.
16	Kestrel	do	610	9 6	One 6″ B. L. R.; three 5″ B. L. R.
17	Ready	do	610	9 10	Do.
18	Rifleman	do	610	10 1	Two 7″ M. L. R.; two 20-pounder B. L. R.
19	Ariel	do	438	10 6	Two 64-pounder M. L. R.; two 20-pounder B. L. R.
20	Zephyr	do	438	10 9	Do.
21	Cygnet	do	455	10 8	Do.
22	Express	do	455	10 4	Two 5″ B. L. R.; two 4″ B. L. R.
23	Contest	do	455	10 6	Two 64-pounder M. L. R.; two 20-pounder B. L. R.
24	Shelldrake	do	455	10 7	Two 5″ B. L. R.; two 4″ B. L. R.
25	Moorhen	do	455	10 5	Do.
26	Mallard	do	455	10 9	Two 64-pounder M. L. R.; two 20-pounder B. L. R.
27	Forward	do	455	10 4	Do.
28	Foxhound	do	455	10 5	Do.
29	Firm	do	455	10 7	Do.
30	Forester	do	455	10 7	Do.
31	Firefly	do	455	10 6	Do.
32	Swift	do	756	10 11	Two 7″ M. L. R.; three 20-pounder B. L. R.
33	Linnet	do	756	10 11	Do.
34	Redwing	do	461	10 10	Two 64-pounder M. L. R.; two 20-pounder B. L. R.
35	Grappler	do	465	10 10	Do.
36	Wrangler	do	465	10 6	Do.
37	Banterer	do	465	10 6	Do.
38	Firebrand	do	455	10 5	Two 4″ B. L. pivots; two 4″ B. L. R. chases.
39	Espoir	do	465	10 6	Two 64-pounder M. L. R.; two 20-pounder B. L. R.
40	Cockchafer	do	465	10 5	Do.
41	Bullfrog	do	465	10 5	Do.
42	Starling	do	465	10 10	Two 5″ B. L. R.; two 4″ B. L. R.
43	Stork	do	465	10 10	Do.
44	Raven	do	465	10 10	Do.
45	Albacore	do	560	12 6	Do.
46	Mistletoe	do	560	11 6	Do.
47	Watchful	do	560	11 6	Do.
48	Esk	Iron	363	9 3	Three 64-pounder M. L. R.
49	Tweed	do	363	9 2	Do.

* The Viper and Vixen are stationed at Bermuda.

TORPEDO VESSELS.

50	Curlew	Steel	785	11	One 6″ B. L. R.; three 5″ B. L. R.
51	Landrail	do	785	11	Do.

DISPATCH VESSELS.

	Name.	Hull, material.	Displacement.	Draught.	Battery.
			Tons.	′ ″	
52	Enchantress	Wood	1,000	11 1	One 6-pounder mortar.
53	Helicon	....do	1,000	10 5	Two 20-pounder B. L. R.
54	Vigilant	....do	1,000	11	Do.

SPECIAL UNCLASSIFIED VESSELS.

55	Magpie	Composite	805	10 6	One 7″ M. L. R.; two 64-pounder M. L. R.
56	Stormcock	Iron	568	10 6	
57	Seahorse	Composite	670	11 11	

Vessels drawing less than 9 feet and over 7 feet.

GUN-VESSELS AND GUNBOATS.

	Name.	Hull, material.	Displacement.	Draught.	Battery.
			Tons.	′ ″	
1	Fly	Composite	603	8 9	One 7″ M. L. R.; one 64-pounder; two 20-pounder B. L. R.
2	Midge	....do	603	8 10	Do.
3	Avon	....do	603	8 10	Two 20-pounder B. L. R.
4	Elk	....do	603	8 10	Do.
5	Pioneer	Iron	576	8 2	Six 20 pounder B. L. R.
6	Cockatrice	Steel	600	8 5	Two 20-pounder B. L. R.
7	Alecto	... do	620	8 5	Four 4″ B. L. R.
8	Triton	Composite	410	7 3	
9	Handy	....do	508	7 8	One 43-ton B. L. R.

TORPEDO VESSELS.

10	Vesuvius	Iron	245	8 6	None.

Vessels drawing less than 7 feet.

	Name.	Hull, material.	Displacement.	Draught.	Battery.
			Tons.	′ ″	
1	Staunch	Iron	180	6 9	One 9″ M. L. R.
2	Plucky	....do	195	6 1	Do.
3	Blazer	....do	254	6 6	One 10″ M. L. R.
4	Comet	....do	254	6 6	Do.
5	Bustard	....do	254	6 6	Do.
6	Kite	....do	254	6 6	Two 6″ B. L. R.
7	Snake	....do	254	6 6	One 9¼″ B. L. R.
8	Scourge	....do	254	6 6	One 10″ M. L. R.
9	Mastiff	... do	254	6 6	Two 6″ B. L. R.
10	Arrow	....do	254	6 6	One 10″ M. L. R.
11	Bloodhound	....do	254	6 6	Do.
12	Fidget	... do	254	6 6	Do.
13	Bonetta	....do	254	6 6	Do.
14	Badger	....do	254	6 6	Do.
15	Bulldog	....do	254	6 6	One 6″ B. L. R.; one 4″ B. L. R.
16	Pike	....do	254	6 6	One 10″ M. L. R.
17	Pickle	....do	254	6 6	Do.
18	Snap	... do	254	6 6	Do.
19	Ant	....do	254	6 6	Do.
20	Cuckoo	....do	254	6 6	Do.
21	Hyaena	....do	254	6 6	Do.

Vessels drawing less than 7 feet—Continued.

	Name.	Hull, material.	Displacement.	Draught.	Battery.
			Tons.	′ ″	
22	Weasel	Iron	254	6 6	One 10″ M. L. R.
23	Medina	do	363	6 0	Three 64-pounder M. L. R.
24	Medway	do	363	6 0	Do.
25	Sabrina	do	363	6 0	Do.
26	Spey	do	363	6 0	Do.
27	Tay	do	363	6 0	Do.
28	Tees	do	363	6 0	Do.
29	Dee	do	363	6 0	Do.
30	Dan	do	363	6 0	Do.
31	Slaney	do	363	6 0	Do.
32	Trent	do	363	6 0	Do.
33	Gadfly	do	265	6 7	One 10″ M. L. R.
34	Griper	do	265	6 7	Do.
35	Pincher	do	265	6 7	Do.
36	Tickler	do	265	6 7	Do.
37	Bouncer	do	265	6 7	Do.
38	Insolent	do	265	6 7	Do.
39	Britomart	Wood	330	×	Two 64-pounder M. L. R.
40	Bineser	do	330	×	Do.
41	Cherub	do	330	×	Do.
42	Cromer	do	326	×	Do.
43	Netley	do	330	×	Do.
44	Oswell	do	330	×	Do.

Each gunboat carries two machine guns.

This list shows that there are 57 vessels drawing less than 12 feet and over 9, 10 drawing over 7 feet, and 44 with less than 7 feet—a total of 111 vessels, 3 of which are armored.

Hostile operations possible from Halifax and Saint John, N. B., on the northeast frontier.—Passamaquoddy Bay and a part of the Saint Croix River form the boundary between the United States and Canada. The islands in this bay belong to Canada, while all the ship channels are also within the Canadian boundary up to the city of Eastport, Me. The resources of the arsenal and dockyard at Halifax are thus immediately available against Eastport, and by means of the Intercolonial Railroad and the New Brunswick Railroad all the connecting roads across the frontier of Maine would in the present state of unpreparedness of the United States be under the control of Canadians. Eastport, Calais, and Vanceborough would all come into the immediate possession of the Canadians, and if an invasion be decided upon, the coast of Maine as far as Portland would soon be a prey to a vigorous attack by the Canadians. No counter-invasion of New Brunswick would be probable, as the facilities for communication and transportation would be chiefly in the hands of the Canadians. The naval supremacy of Great Britain would co-operate to effect the invasion of Maine up to the city of Portland.

*From Quebec.**—The proposed bridge over the Saint Lawrence will give Quebec some additional advantages for hostile operations, but the distance from the frontier and the small and unimportant points exposed would render direct operations improbable. The chief purpose likely to be served would be co-operation with movements for hostile operations from or for the defense of Montreal. The Intercolonial Railroad, Grand

* The proposed bridge at Quebec. See Scientific American, May 30, 1885.

Trunk, and Great Northern Railroads, with their connections, would afford transportation for all the troops available, especially if assisted by the Saint Lawrence shipping as far as Montreal. The railroad facilities would combine to render any attack for the control of the Saint Lawrence River between Quebec and Montreal very difficult.

Montreal.—The metropolis of the Dominion of Canada, with a population of 140,000. It is on the south side of the island of Montreal in the Saint Lawrence River, which is here two miles wide, spanned by the Victoria Bridge. This bridge is 9,184 feet long, with 24 spans, the center one of which is 60 feet above the river. It is at the head of the ocean navigation and at the commencement of the river and lake navigation, and the chief center of the railroads of Canada. The Lachine Canal is a portion of an extensive system of artificial docks and quays built of gray limestone.

The Richelieu and Lake Champlain navigation commences at Sorel, at the mouth of the Richelieu River, on Saint Lawrence River, 45 miles northeast of Montreal, and this route has been previously described, so that in connection with the numerous railroads on the frontier between Montreal and the United States the advantages of communication are decidedly in favor of the Canadians.

"The line of Lake Champlain was long regarded as offering the only practicable means for a hostile advance into Canada. Of course the conditions have long since changed, but it gives what is still perhaps the most direct and feasible route to the capital and principal cities, besides cutting most speedily the great line of water communication upon which that country must depend. As the system now exists the heaviest siege guns with their carriages and ammunition may be shipped direct from the foundries and arsenals to the northern line, as may also military supplies of every description from New York and Philadelphia."*

The distance from New York to Rouse's Point by rail, New York Central and Hudson River Railroad and Delaware and Hudson Canal Company's Railroad via Albany, is 353 miles, while the distance from Montreal by rail is only 50 miles. Again, the distance from the Saint Lawrence River by the Richelieu and Lake Champlain water route, Sorel to the boundary, is 81 miles, while that from New York to the boundary line, via Hudson River to Albany, Erie Canal Junction, the Champlain Canal, and Lake Champlain, is 331 miles, the depth of both sections being the same, 7 feet.

The quantities of ordnance stores and war material possessed by the United States compared with that which is in reserve or very quickly available by the Canadians at Montreal would, in the present condition of the defenselessness of this frontier, give the Canadians immense advantages upon the first breaking out of hostilities between the United States and Canada.

These transportation facilities are more than sufficient for the concentration of the Canadian forces at the head of Lake Champlain, Saint Albans, Rouse's Point, and vicinity. The left flank of the enemy would be conserved intact by their communications with Three Rivers and Quebec to enable them to prevent all attempts to gain possession of the banks of the Saint Lawrence east of Montreal. The right flank of this base would also be protected by the railroads from Montreal as far as Dundee, while the result of their operations, due to the naval supremacy they would soon have on the river, would

* From Thesis on Inland Canal Communication, by Lieut. T. H. Bliss, United States Army.

soon bring all the New York bank of the Saint Lawrence River, including the city of Ogdensburg and the two United States frontier railroads (Odgensburg and Lake Champlain Railroad, and the Rome, Watertown and Ogdensburg Railroad) as far as Cape Saint Vincent, into their possession.

Kingston, Toronto, and Hamilton would serve as bases for naval operations on Lake Ontario. Sackett's Harbor and Oswego would probably hold out sufficiently long to enable the United States to develop her resourses and bring a force to their relief. The latter place by its railroad connections and the Oswego Canal would soon be in a condition to serve as a base for an offensive defense of the frontier.

Sodus Bay would invite a landing by the enemy in control of Lake Ontario. By doing so the raiding parties from such a base could sever the Erie Canal between Rochester and Syracuse, besides cutting the several lines of railroads through northwestern part of New York.

At Charlotte the Genesee River may be obstructed to protect approaches to Rochester. The resources and communications of this city would contribute so much to its defense that it would soon be able to carry on an offensive defense of the frontier.

The Welland Canal.—The object of this canal is to furnish a navigable route from the upper lakes to Montreal. When all the canals and works of this navigation are completed, vessels drawing 13 feet of water will be able to load at any port on the lakes and proceed direct to Liverpool without any necessity for handling cargo; while the distance from Liverpool to the lake ports via Montreal is 480 miles less than that to the same port via New York. In the event of war with the United States this system of navigation will enable the British Government to assemble a fleet of light-draught gunboats armed with heavy rifled guns and a fleet of torpedo boats, of which the British navy have a great number of each, while the United States at present have none.

The four bridges over the Niagara River, viz, the Suspension Bridge, Cantilever Bridge, International Bridge, and the small Suspension Bridge to Clifton at Niagara Falls, might by a bold dash be secured by the Americans. The vast excess of population on the American side of the river renders the success of such a movement at the first breaking out of hostilities apparently probable, at least for one of the bridges mentioned.

The British Government has spent over $54,000,000 upon the Welland Canal, and it is scarcely possible that it would be left so exposed as might be inferred. The splendid railroad communications, the commercial and naval supremacy on the lakes possessed by the British would enable them to concentrate such a force with ordnance and war material as to render the approaches by a hastily formed, undisciplined, and poorly equipped force of Americans (such only being now available) practically impossible.

This navigation of the Saint Lawrence and the lakes by the Welland Canal renders the treaty stipulation that the United States and Canada shall each keep but one naval vessel on the lakes practically a dead letter, because the British have a fleet of vessels and torpedo boats which if not on the lakes can get there in a few days, while the United States have no facilities for getting vessels drawing more than 6 feet on the lakes, except through British waters.

Surveys and estimates were made by authority of Congress in 1867 for a ship-canal in New York State around Niagara Falls. Length of lock-chamber, 275 feet. Width of canal at surface, 125 feet; at bottom, 100 feet. Depth 14 feet. Five routes were examined. The report of the Chief of Engineers United States Army, 1868, states, viz: "The Eighteen-Mile Creek route best fulfills the condition of security by being further removed from the frontier, and as its terminus is 15 miles farther east on Lake Ontario than the average of the others, viewed as a route for commerce, it is that much shorter. Its greater security against secret enterprises during and just preceding a war renders it preferable for commercial as well as for military and naval purposes."*

Nothing further has been done to construct this permanent ship-canal, the only possible offset to the strategical importance of the Welland Canal. In addition to this, the Erie Canal should be enlarged to take light-draught gunboats drawing 13 feet. The upper part of the Mississippi should be improved in connection with the Hennepin Canal, Illinois River, and the Illinois and Michigan Canal to Chicago, thus completing the chain of inland navigation throughout the country, from New York via Erie Canal and the new Niagara Canal, Lakes Erie, Huron, Michigan, to Chicago and down the Mississippi.

Having detailed the resources and communications of the Canadian and American cities and towns along the upper lake shores, further consideration of the exposed points is hardly necessary. This region is very near the center of population in the United States, which is now moving westward to a point between Saint Louis and Chicago. That portion of the Canadian province of Ontario between Lakes Erie and Huron would, notwithstanding the lack of war material, soon come under the control of the Americans, because of the immense preponderance of men and resources in their favor. An offensive defense would be practicable by an invasion of this peninsula by obstructing the navigation of the Detroit and Saint Clair Rivers to prevent the effectual co-operation of the British gunboats which will have entered from the Welland Canal as soon as hostilities commence.

II. The New England and Atlantic Seaboard.

In this connection merely those places which are likely to be seized by a vastly superior naval force for extensive operations on the coast will be considered, with the advantage and disadvantages offered by the navigable routes and railroad communications for an offensive defense of the vicinity threatened by the operations of such a hostile force.

"In the event of a foreign war that would seriously tax the energy of the Government we would find ourselves with a vast army suddenly collected along some one of our maritime frontiers. It is possible that at the outset we shall find some of our large seaboard cities, where commercial enterprise has collected vast stores of food and other material, to which we would naturally look for supply, in the hands of an active and enterprising enemy. Our railroads would then be taxed beyond their

*Report of Chief of Engineers United States Army, 1868.

capacity for the transportation of men, food supplies, and war material. In which case the immense advantages of inland water communication would be obvious These routes are in some respects safer in time of war than railroads, for any ordinary raiding party can cut railroad communication by a few minutes' work, while the obstruction of the water routes would be difficult and also be a labor of some time."*

One of the most remarkable features in the geographical formation of our country is what has been called "*a second coast line*," formed by making a navigable channel near to and parallel with the coasts on the Atlantic and Gulf, and having numerous connections with those waters and interior rivers and canals. Its military value has been urged by our most distinguished engineers for many years, and two advantages are obvious: it would enable the Government to transfer our ships of war by a safe and speedy route, in the presence of a superior naval force, from one point on our coast to any other, and would preserve our vast coasting trade in uninterrupted activity throughout the war.

This navigable channel forming the "second coast line" begins in the great bay north of Cape Cod and passes overland either into the Narragansett or Buzzard's Bay, Long Island, New York Harbor, the Raritan River to New Brunswick, the Delaware and Raritan Canal to the Delaware River at Bordentown, Delaware River and Bay to Delaware City, the Delaware and Chesapeake Canal to Chesapeake Bay, to Hampton Roads, Elizabeth River, the Dismal Swamp Canal, the Albemarle and Chesapeake Canal, Albemarle Sound; thence through the swamp land-locked sounds and lagoons of the Carolinas and Georgia to Florida, overland to the Gulf of Mexico, and thence through interior sounds and bayous to New Orleans.

The New England coast, from Eastport to Cape Cod, cannot be considered to be in a state of defense, as all of the bays and harbors are exposed to attack from a powerful hostile naval force. In considering the nature of such an attack it would necessarily, except in case of war with England, be carried on from a very distant country, and the desirability of a base for hostile operations on this coast would be very great, provided such places nearer New York and Washington could not be gained.

Penobscot Bay, with its numerous outlying islands, would afford an admirable site for such a base. There are a number of harbors of refuge in this vicinity. In Frenchman's Bay, Winter Harbor and Stave Island Harbor are important harbors and could be taken possession of by a powerful naval force to operate upon our coast. In Penobscot Bay there are a number of similar harbors where an enemy may effect a lodgment for a naval base of operations, but on the New England coast no important lines of communication would be severed except the coastwise trade, and except in case such a landing be taken in co-operation with an invasion by the British from New Brunswick into Maine to gain possession of the cities of Maine, the facilities and resources of which may be then utilized for a more extensive series of operations.

The following is list of the larger bays and harbors undefended and which might be taken by a hostile force for bases of operations:†

Passamaquoddy Bay.—The best channels of which, leading to Eastport, Me., and to other points on the Saint Croix River, belong to Great Britain.

* Thesis on Inland Canals, by Lieut. T. H. Bliss, United States Army.

† Atlantic Coast Pilot A; United States Hydrographic Charts; United States Coast and Geodetic Surveys.

Machias Bay is of no importance; the navigation is difficult, and an enemy would gain no advantage by its occupation.

Englishman's Bay.—This is 5 miles long to the entrance of Chandler's Run at its northern end. It is 7 miles wide, with a number of small islands on it, forming the channels in which the least depths are from 5 to 6 fathoms, good for the largest vessels.

Narraguagus Bay.—Large and commodious; 2 miles wide and 4 miles long to the mouth of the Narraguagus River.

Frenchman's Bay.—Fourteen miles long and 6 to 7 miles wide. Deep and easily accessible. Within its limits are *Winter Harbor*, one of the best and most accessible on the coast. This is the most available site undefended on the coast. Stave Island Harbor and the other coves are of less importance.

Blue Hill Bay.—Fifteen miles long with average width of 6 miles. It is studded with islands and its navigation difficult.

Penobscot Bay.—The most extensive of the bays of the coast of Maine. It begins at Isle au Haut on the east and extends to White Head on the west, between which points the bay is 20 miles wide. The mass of islands about midway divide it into two parts—East and West Penobscot Bays Its length from entrance to the mouth of the Penobscot River is 28 miles. Many towns and villages are situated on the shores of its harbors, rivers, and coves. Fort Knox is at Bucksport, at the mouth of the narrows of the Penobscot River, 18 miles below Bangor, Me. This fort would afford a defense for the security of this harbor of refuge for coast shipping. It is a casemated work with exterior earthen batteries, both requiring extensive modifications.

Muscongus Bay is the next bay west of Penobscot Bay. It is 8.4 miles wide, and the coast indentations are prolonged by rivers, coves, and sounds, the largest of which is Muscongus Sound, 2½ miles long and ⅞ of a mile wide. This bay is studded with islands, some of which have excellent harbors, and none are defended.

John's Bay is 1½ miles wide at its entrance and extends with the same width for 2¾ miles, where it has two arms, one of which, Pemaquid Harbor, is an excellent harbor of refuge for strangers.

The mouth of *Damariscotta River* is the next opening on the coast west of John's Bay. The entrance is 1¾ miles wide, and its navigable length up to the bridge between the ship-building towns of Newcastle and Damariscotta is 14 miles. There are a number of towns on the banks; no defenses.

Linekin's Bay is a commodious deep harbor with least depth of 5 or 6 fathoms. The bay is 2½ miles long and 1 mile wide. The entrance is but 1,100 yards wide, and the available channel only 500 yards. It is only used as a harbor of refuge, and it would be a favorable site for a hostile naval base.

Booth Bay is an arm of the sea 4 miles long, and separated from Linekin's Bay by the land forming the cove at the head of Town's End Harbor; the latter is a good harbor of refuge and also available for an enemy.

Sheepscot River empties into *Sheepscot Bay.* It is very deep; 9 fathoms can be carried in the channel up to the town of Wiscasset, 14 miles above its mouth. There

are a great many islands and coves, but the best harbor is that of Wiscasset, a place of 2,000 inhabitants. The natural advantages of this harbor can scarcely be surpassed. There are no defenses.

Kennebec River is one of the most important trade routes by water in Maine. The city of Bath is 12 miles from the entrance. It has 10,000 inhabitants and is the leading wooden-ship-building city in the United States. The entrance is to be defended by Fort Popham, at present unfinished.

Casco Bay occupies a coast width between the headlands of about 17¾ miles, between which the bay extends up into the land for an average distance of 12 miles. It is full of islands, and the shore line is much cut up by rivers and long deep coves. There are 136 islands in Casco Bay, many very fertile and under cultivation, and nearly all inhabited. The city of Portland is situated on a peninsula on the west shore of the bay. Portland harbor is defended by Forts Gorges, Preble, Scammel, and the Battery on Portland Head. Plans have been designed for the construction of batteries on Cow Island and Great Hog Island to defend approaches to Portland Harbor and prevent the occupation of Casco Bay by an enemy.

Richmond Island Harbor is a small semicircular bight between the northwest side of the island and the coast line, Seal Cove being similarly formed on the northeast side; the latter is full of dangers to navigation, but the former is an excellent harbor of refuge and is easily entered when vessels cannot get into Portland.

Saco Bay has no advantages for an enemy.

Portsmouth Harbor is formed by the lower reaches of the Piscataqua River, which empties into the ocean between Gerrish's Island on the east and Great Island on the west. This is the site of an important naval station. It is defended by Forts McClary and Constitution, the battery on Gerrish's Island (incomplete), and battery on Jerry's Point (also incomplete).

Rockport Harbor forms the best harbor of refuge on the northern shore of Cape Ann, situated at the bottom of Sandy Bay. This bay is nearly 2 miles at its entrance and 4 miles long to the entrance of Rockport Harbor.

Massachusetts Bay is contained between the headlands of Cape Ann and Cape Cod. On a line joining these two capes it is 38 miles wide, and its greatest length from this line to the main shore is 22 miles. Within its limits are contained the important harbors of Gloucester, Salem, Boston, Plymouth, and Provincetown.

Gloucester Harbor is formed by an arm of the sea indenting the southern shore of Cape Ann. It is 2½ miles wide, and its whole length 2½ miles. Gloucester is the headquarters of the fishing interests of Massachusetts. It has a very active, enterprising sea-faring population. It is undefended, and if it should fall into the possession of a powerful naval force the offensive defense by this valuable auxiliary naval force would be greatly weakened.

Salem Harbor is the western end of a large indentation of the northern shore of Massachusetts Bay. The headlands of this indentation are 4 miles apart, and the wide space is studded with islands and includes the harbors of Manchester, Beverly, Salem, and Marblehead. The defenses are Fort Sewall, Marblehead Harbor; a small field work.

Boston Harbor and navy-yard defended by Fort Warren, battery at Long Island Head, and Forts Winthrop and Independence.

Cape Cod Bay is a large nearly circular bay between Cape Cod on the east and south and the mainland on the west. It is about 10 miles in diameter, with deep water, from 10 to 27 fathoms except close to the shore, and is almost entirely unobstructed. From Race point to Gurnet Point (the eastern and western headlands) the distance is 16¼ miles W., ½ S. Within the limits of Cape Cod Bay there are the harbors of Duxbury and Plymouth on the west, Barnstable and Yarmouth on the south, and Wellfleet and Provincetown on the east. All but last named are shoal and only used by coasters and fishermen.

Provincetown Harbor is formed by the northern end of the hook of Cape Cod and is one of the most important harbors of refuge on the coast of the United States. It is easy of access, has good holding ground, and sufficient water for the largest vessels. It is very much exposed to the hostile operations of a powerful naval force, and it would be one of the first sites to be selected for such a purpose, its proximity to the city of Boston and the control of the vast commercial resources of the New England States rendering it very important, and at present there are no defenses.

Sandwich Harbor, in the southwestern part of Cape Cod Bay, is at present a very unimportant place and the entrance is very narrow and difficult, but this place is to be the entrance to the ship-canal from Cape Cod Bay to the head of Buzzard Bay. This canal is of the greatest importance, but it is as yet only a proposed work. This canal, when completed, will form the first link in the chain of inland water route along our coast to form the "second coast line." The necessities of navigation render the construction of this canal absolutely imperative, and it is now only a question of time when it will be done. The strategical value of this canal cannot be overestimated.

"The proposed canal from Barnstable to Buzzard's Bay is to be 7½ miles long and to have an average depth of 23 feet at mean low water. The bottom width is to be 75 feet and surface width 200 feet. A harbor is to be formed at Barnstable by two breakwaters forming a basin to protect the opening of the canal. These breakwaters will enclose an area of 140 acres. The north breakwater to be 4,000 feet long and the southern one 2,000 feet long. The opening between the outer extremities of these breakwaters to be 700 feet. The Buzzard's Bay end of the canal will require considerable dredging to get an average depth of 23 feet down as far as Wing Neck Lighthouse. The only work so far is preliminary or prospecting. One dredger, 'The Ball Dredger,' is at work on the Barnstable end of the canal. The capacity of this dredger is between 3 and 4 thousand cubic yards in 10 hours' work. The diggings are conveyed off into the marsh by means of iron pipes (13 inches in diameter) to a distance of 800 feet."*

The east shore of Cape Cod is an exceedingly dangerous coast, along which the United States Government has established 8 life-saving stations.

Nantucket Sound is the common thoroughfare for coasting vessels between New York and Boston; it is bounded on the north by the mainland of Massachusetts, the east by the Atlantic Ocean (Nantucket Shoals), south by Nantucket Island, and west

*Register No. 3999.

by Martha's Vineyard. Within these boundaries it is about 18 miles in diameter, and has wide channels with water sufficient for the largest vessels; but it is full of shoals and dangers. The harbors of this sound are small and very poor, and would be of little importance.

Vineyard Sound is bounded on the north by the mainland and a chain of islands called Elizabeth Islands, and on the south by Martha's Vineyard. Between Succonnesset Point and Cape Poge the sound is about 8 miles wide, but at West Chop (the northern extremity of Martha's Vineyard) it contracts to 3½ miles wide, which width it maintains to Gay Head. The total length of the sound in these limits is about 20 miles, and contains sufficient water for the largest vessels. Its shores are for the most part clear, the shoals lying mainly in the axis of the sound, with wide and deep channels among them affording beating room for the largest vessels. There are several good harbors on both shores, viz: Wood's Holl, Tarpaulin Cove, Edgartown Harbor, and Vineyard Haven.

Edgartown Inner Harbor has a channel of 15 feet, good holding ground in 3 to 5 fathoms, but its importance is very slight in this connection, Vineyard Haven being of much more strategical value.

Vineyard Haven or Holmes's Hole is a wide, deep indentation in the northern shore of the island; it is sheltered from the southerly and westerly winds, and has from 3 to 5 fathoms of water. This bight is 1½ miles long and a little over 1½ miles wide at its mouth. There are no defenses, though fortifications on West Chop would command the passage of the sound, here about 3½ miles wide. The occupation of this harbor and of the island by an enemy would afford a base for important operations.

Wood's Hole is a somewhat crooked passage leading from Vineyard Sound to Buzzard's Bay. It is between the mainland and eastern side of Nonamessett Island, the easternmost of the Elizabeth Islands. The passage through to Buzzard's Bay is full of dangers. There are a number of harbors, the largest of which, Great Harbor, has good anchorage from 4 to 10 fathoms, sheltered from all winds. There is a breakwater 40 yards connecting Long Neck Island with the mainland to form the harbor. This harbor would be of great value to an enemy for hostile operations, especially if held in connection with that of Vineyard Haven.

Tarpaulin Cove is a most excellent harbor of refuge, 4 miles west of Wood's Holl. Its strategical value for hostile operations of an enemy is dependent upon Wood's Holl and Vineyard Haven for the control of the navigation of the sound.

Quick's Hole is strictly a passage and not a harbor, but it affords shelter and an anchorage. It is three-fourths of a mile wide between Pasque and Nashamena Islands; it is deep and available for strangers. It is of value in considering the command of Vineyard Sound.

Buzzard's Bay is that large indentation in the southern coast of Massachusetts north of Elizabeth Islands. It is 20 miles long with an average width of about 5 miles, and has deep water throughout its length and breadth. The width of the entrance between Gooseberry Neck and Cuttyhunk Point is about 5½ miles, with a depth of from 9 to 12 fathoms in mid channel.

The harbors of Buzzard's Bay are Cuttyhunk Harbor, Quamquisset, Cataumet, Pocasset, Monument, Wareham River, Weweantic River, Wing's Cove, Sippican, Mattapoisett, New Bedford, Apponeganset Bay, and Slocum's River. All of these are full of shoals and dangers; the most important is that of New Bedford Harbor.

When the Cape Cod Ship Canal is constructed a good harbor will be formed in the northeastern part of the bay. There is a fort at Clark's Point commanding the entrance to New Bedford Harbor. Other defenses could be readily constructed to command the entrances to the bay.

Narragansett Bay is strictly contained between Judith Point on the west and Sakonnet Point on the east, but by custom the southwest point of Rhode Island, Brenton's Point, is considered the eastern point of the entrance. The waters lying east of Rhode Island and west of Pakonnet Point form the Sakonnet River communicating directly with Mount Hope Bay and Taunton River, and, by a passage between the northern end of Rhode Island and Bristol Neck, with Narragansett Bay, Bristol Harbor, and Providence River. The entrance to Sakonnet River is 2½ miles wide between Sakonnet Point and Sachuest Point. It is one-fourth of a mile wide at the stone bridge where this river joins Mount Hope Bay. From its entrance to the bridge it is 12 miles long and there is not less than 3½ fathoms in the channel. It is very little used at present, owing to absence of buoys on the upper flats and the loss of time in passing through the bridges. It would afford an easy and commodious passage into Mount Hope Bay and to Fall River.

The entrance to Narragansett Bay between Point Judith and Brenton's Point is 4½ miles, which is divided into two channels by Conanicut Island. The bay lies N. by E. and S. by W. and is 15 miles long from Brenton's Point to Providence River, at its head. Its width varies. The shore line is irregular and the bay is full of islands and islets. Conanicut and Providence are the largest. Several important towns are built upon its shores—Newport, Wickford, Bristol, and Greenwich. On its eastern side it communicates with Mount Hope Bay and Taunton River—the site of the important manufacturing town of Fall River, and, at its head through Providence River, with the city of Providence.

Newport is an important naval station and the site of the United States naval torpedo station. The entrance of the bay forms one of the best roadsteads on our coast. It is defended by Fort Adams on the east and earthen batteries on Dutch Island on the west.

Block Island Sound is the name of that large body of water westward of Point Judith to Gardiner's Island. It is 26 miles long and 8½ miles wide at the eastern end between Block Island and Point Judith, and its greatest width between Montauk and Watch Hill Points is 13¾ miles. Block Island Basin is an artificial harbor constructed by the United States Government for the shelter of small vessels. The basin is formed by a heavy stone breakwater. The basin is nearly square, 130 yards in diameter, and a uniform depth of 7 feet.

Fisher's Island Sound is an important thoroughfare between the mainland of Connecticut and Fisher's Island. It is little over 7 miles long; it is not considered safe for strangers on account of a dangerous line of reefs between East Point and Watch

Hill Point. On the northern side are the important harbors of Stonington and Mystic, while there are convenient anchorages formed by indentations on the northern shores of Fisher's Island.

Little Narragansett Bay is wide, but very shallow, and only navigable for vessels of the lightest draught.

Long Island Sound is an extensive body of water between the shores of Connecticut and New York on the north and Long Island on the south. It is between 80 and 90 miles long. It is widest at about midway of its length, between Bradford Harbor and Hearld's Point, where it is 16 miles wide. At its eastern entrance, between Fisher's Island and Plum Island, it is about 6½ miles wide, while between Throg's Neck and Willets Point it is only three-fourths of a mile wide. This sound forms a most important part of the inland coast navigation. Four-fifths of the coastwise trade from New York to New England ports pass through it. The important harbors of New London and New Haven are on its northern shore, with a number of "tidal" harbors for light-draught coasters. On the southern shores are Greenport and Sag Harbor (in Shelter Island Sound), Huntington and Oyster Bays, Hempstead and Manhasset Bays, all of which except the last named can be entered at low water by vessels drawing 18 feet. Long Island Sound is singularly free from dangers throughout its entire length; affords ample room for beating to windward and good anchorage in bad weather. The passage of Hell Gate, in the Narrows of East River, has been an obstacle hitherto, but this is being constantly improved. The available channel at the entrance is contracted to a width of 3½ miles by the Gull Islands, which lie about midway between Plum Island and Race Point, and Valiant Rock is midway between Race Point and Gull Islands.

Plum Island and Gull Islands would, if fortified, command the eastern entrance to the sound.

New London Harbor is the easternmost of the sound. It is formed by the southern portion of the Thames River from New London to its mouth. The river is formed by the junction of the Quinnebaug, Shetucket, and Yantic Rivers at Norwich, whence it flows nearly south for 15 miles. It is navigable for nearly the whole of this distance. The entrance is about 1 mile wide. The entrance is defended by Fort Trumbull and Fort Griswold, on opposite sides.

Niantic Bay is an indentation on the northern shore of Long Island Sound, 1½ miles long, with an average width of 1¼ miles. There is good anchorage in from 12 to 21 feet, easy of access, and sheltered, except from the south. It is, however, of very little importance.

Connecticut River entrance is 11½ miles west of New London entrance. It is about 1 mile wide, but it is so surrounded by shoals as to render its navigation difficult. There are no defenses, but the river could be easily obstructed.

New Haven Harbor is defended by Fort Hale, a temporary work on a valuable site. This small work commands the harbor against the small vessels that might enter.

Stratford Harbor, at the mouth of the Housatonic River, cannot be entered by strangers on account of the bar at its mouth.

Bridgeport Harbor, at the mouth of Pequannock River, has a very narrow channel, with but 12 feet at low water.

Huntington Bay lies on the southern side of the sound. It is 2½ miles long north and south, with an average width of 1¼ miles. It affords excellent anchorage in 3 to 6 fathoms, and shelter, except to the northwest. At its southern end it is connected, by a passage one-half mile wide, with Northport Bay. This bay is irregular in shape, lies east by west, and is a little over 2 miles long. It is 1¼ miles wide in widest part, and in no place less than five-eights of a mile wide. This can be safely entered from Huntington Bay through a channel 100 yards wide, with 3½ fathoms. The anchorage is sheltered and has 4 to 9 fathoms.

Oyster Bay is the next harbor west of Huntington Bay. It is irregular in shape, and divided into two parts by Centre Island—one called Cold Spring Harbor and the other Oyster Bay Harbor. The channel is 300 yards wide, with not less than 6 fathoms, and good anchorage. Cold Spring Harbor has 15 to 17 feet and Oyster Bay Harbor 2 to 5 fathoms. The town of Huntington is only 35 miles from Brooklyn, by Long Island Railroad, and the importance of these undefended bays (Huntington and Oyster Bays) is apparent, in considering the strategical advantages of this bay for a base of operations against New York. No defenses.

Hempstead Harbor is only available for small vessels.

Manhasset Bay is irregular in shape, 4 miles long and seven-eights of a mile wide atits mouth. It is deep and sheltered, but only 14 feet can be taken across the bar at its entrance.

New Rochelle Harbor is on the northern side of the sound, opposite Manhasset Bay. It is shallow and of no importance.

Pelham Bay and Hutchinson's River are only fit for the smallest vessels.

Throg's Neck, the southern point of the entrance, is the northern point of entrance to East River, and on it is Fort Schuyler, defending the entrance to New York. The fort at Willets Point is designed to co-operate with Fort Schuyler for the defense of this approach to New York.

Gardiner's Bay is at the eastern end of Long Island, which forms the northern shore of the bay. The eastern shore is formed by Gardiner's and Rain's Islands and the reefs connecting them. Its southern shore is formed by a part of Long Island, and its western by Shelter Island. The bay has an average diameter of 6 miles, and is singularly free from dangers. The depth is from 3½ to 8 fathoms throughout, and affords beating room for large vessels. Shelter Island Sound also has deep water, but its channel is narrow and obstructed by shoals. Little Peconic Bay and Great Peconic Bay are also connected with it. There are three entrances to Gardiner's Bay—two from Block Island Sound and one from Long Island Sound. But only one of those leading from Block Island Sound is available, and it is the principal and only safe entrance for strangers. This lies between Pine Point (the southwest end of Plum Island) and Gardiner's Point. It is 2½ miles wide, with a depth of from 3 to 20 fathoms, and entirely unobstructed. The entrance from Long Island Sound is through Plum Gut, 1¼ miles wide, with an available channel five-eighths of a mile wide. There are two detached shoals in the channel. There is, however, plenty of water in the gut

for the largest vessels, but the velocity of the current is difficult for sailing vessels to stem. The third entrance, southernmost, leads from Napeague Bay. Its channel is narrow and crooked and full of shoals. The site of Gardiner's Bay and its natural advantages for a great harbor are such as to render it one of the most important on the coast. Commercial enterprise has advocated it as a terminus of the transatlantic navigation, and its strategical value as a base for hostile operations is of the very highest importance. There is no place on the Atlantic coast which would give an enemy greater advantages for hostile operations on our coast. Its possession would afford a most desirable site for the collection of his stores and war material, and enable him to establish a naval port which would threaten the maritime resources of the entire Atlantic coast. Once in the possession of an enemy, it would seriously tax the energies of the Government to dislodge him, especially if, as is supposed in this paper, this enemy possesses an undoubted naval supremacy on the high seas—such as is the case at present with any of the great European powers.

The following statistics serve to show the strength of the merchant marine of the United States available as auxiliary navy or liable to be a prey to the depredations of commerce destroyers:

Merchant steam tonnage and traffic on United States waters with a navigable outlet.

[Tenth Census of the United States, 1880. Report of Steam Navigation, page 46.]

States.	Number of steamers.	Tonnage.	Value of steamers.	Crews, persons.	Capital invested.	Gross earnings.	Passenger traffic, number.	Freight traffic, tons.	Fuel used.	
									Coal, tons.	Wood, cords.
Maine	87	16,344.36	$1,098,300	724	$1,903,100	$892,678	530,282	301,862	42,009	1,776
New Hampshire	7	267.79	30,600	24	35,200	20,980	11,500	.....	630	15
Vermont	10	2,246.26	212,300	102	217,250	103,214	92,492	2,530	4,150	1,208
Massachusetts	173	48,885.68	3,257,500	2,298	5,217,250	3,240,652	13,035,790	694,079	131,414	811
Rhode Island	70	21,486.52	1,539,650	1,055	3,245,100	1,485,952	831,079	419,939	53,195	2,564
Connecticut	116	29,323.13	1,752,200	1,442	3,125,300	2,106,352	973,567	1,192,006	143,682	2,199
New York	876	279,244.53	21,007,150	11,028	33,535,681	22,357,754	93,370,484	3,270,839	799,533	7,194
New Jersey	163	41,811.17	2,462,150	1,271	2,943,450	2,615,793	39,991,653	1,669,231	109,030	1,884
Pennsylvania	202	54,086.66	4,516,310	1,982	5,671,243	3,366,763	1,227,714	1,065,732	210,357	820
Delaware	25	5,877.97	302,300	229	497,800	139,933	67,590	152,760	8,461	1,749
Maryland	158	44,837.16	3,870,950	2,521	4,609,950	3,075,640	908,832	995,353	124,717	870
District of Columbia	34	6,945.77	505,000	237	832,960	300,576	87,009	63,500	20,739	125
Virginia	89	6,251.02	494,400	491	526,350	567,793	1,566,609	139,048	29,904	3,621
North Carolina	52	3,850.86	205,700	335	231,900	419,964	29,421	189,219	5,030	14,569
South Carolina	41	5,242.10	242,700	332	397,850	386,260	135,604	97,264	7,889	19,657
Georgia	44	13,331.46	1,387,300	494	1,686,500	1,091,430	34,701	114,030	22,045	15,831
Florida	70	6,826.70	448,500	587	638,800	510,808	40,417	76,926	10,037	26,073
Alabama	43	7,168.17	257,600	702	421,700	437,465	51,237	184,187	240	38,528
Louisiana	18	25,421.68	2,555,000	514	2,600,000	1,654,843	13,533	278,469	28,144	.....
Texas	35	4,351.91	196,900	350	345,466	336,456	4,803	168,422	3,697	11,112
California	178	58,828.80	3,763,200	1,970	5,916,836	4,011,384	6,309,502	1,561,256	137,349	14,123
Oregon	89	31,370.94	2,177,000	788	2,394,754	1,983,703	159,903	476,898	8,233	22,889
Washington	52	6,805.14	537,300	250	542,900	367,983	185,307	49,139	825	66,434

Number and tonnage of sailing vessels, steamers, canal-boats, barges, and vessels engaged in cod and mackerel fisheries, for the year ending June 30, 1884.

[Annual Report chief of Bureau of Statistics, Treasury Department. Commerce and Navigation of the United States, year ending June 30, 1884, pages 1005–1015.]

State and district.	Sailing vessels.		Steam vessels.		Canal-boats.		Barges.		Fishing vessels— Over 20 tons.		Fishing vessels— Under 20 tons.	
	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.
MAINE.												
Passamaquoddy	171	15,557.28	16	4,416.34					10	396.16	21	278.80
Machias	187	20,792.28	7	159.76					8	254.48	22	275.29
Frenchman's Bay	231	14,578.82	5	124.70					27	1,560.26	29	324.29
Castine	251	14,112.96	1	25.28					33	2,209.06	27	340.28
Bangor	170	26,719.49	12	805.88					1	34.23	7	97.84
Belfast	248	51,520.72	4	156.83					32	1,664.48	34	375.11
Waldoborough	368	83,533.23	4	1,137.89					72	2,825.69	79	984.52
Wiscasset	150	7,326.00							33	1,838.92	38	427.42
Bath	265	168,631.01	32	4,400.32			2	718.25	2	86.87	13	131.76
Portland and Falmouth	357	108,393.18	30	11,506.68					104	6,129.81	38	572.73
Saco	14	2,272.77	3	231.07							5	44.50
Kennebunk	38	5,916.77							7	213.72	10	102.98
York	12	395.52									3	28.38
Total	2,462	519,749.33	114	22,964.55			2	718.25	329	17,213.48	326	3,394.36
NEW HAMPSHIRE.												
Portsmouth	63	10,195.98	7	377.55					13	492.08	8	115.18
MASSACHUSETTS.												
Newburyport	54	17,907.06	16	916.28			2	86.86	10	331.24	9	94.29
Gloucester	495	31,693.16	1	68.80					338	22,849.61	62	747.10
Salem and Beverly	38	1,740.82	3	31.04					9	669.47	16	191.43
Marblehead	42	2,776.59							22	1,110.31	13	145.90
Boston and Charlestown	657	227,455.66	132	34,381.54					56	3,121.81	8	69.51
Plymouth	45	2,407.81							9	606.61	14	141.39
Barnstable	312	30,935.78							167	13,665.46	36	412.09
Nantucket	17	474.87	2	1,062.37							13	88.53
Edgartown	26	1,572.35									3	18.37
New Bedford	196	34,659.25	12	2,320.41					9	610.67	35	381.09
Fall River	75	21,400.93	22	21,846.28			9	3,626.28			9	115.95
Total	1,957	373,024.28	188	60,626.72			11	3,713.14	620	42,965.18	218	2,405.65
RHODE ISLAND.												
Providence	105	14,415.33	37	19,889.09							39	320.29
Bristol and Warren	27	1,672.80	7	217.53							3	26.76
Newport	100	3,724.32	15	1,580.28					11	1,121.42	45	494.03
Total	232	19,812.45	59	21,686.90					11	1,121.42	87	841.08
CONNECTICUT.												
Stonington	91	5,088.81	12	1,375.74					25	1,179.29	43	437.50
New London	131	12,272.71	46	16,516.28			15	3,892.67	32	1,410.14	33	456.10
Middletown	59	6,274.18	19	4,268.65			19	3,788.60				
New Haven	115	17,742.87	47	8,498.62			135	18,953.11				
Fairfield	142	5,342.51	28	4,957.52	2	251.69	2	226.28				
Total	538	46,720.54	152	35,616.81	2	251.69	171	26,860.66	57	2,589.43	76	893.60
NEW YORK.												
New York	2,488	312,401.33	1,044	361,438.82	209	21,196.78	454	90,715.91	20	1,643.10	113	781.66
Sag Harbor	221	10,722.39	28	2,311.67			1	781.30	54	5,359.31	88	864.47
Total	2,709	523,123.72	1,072	363,750.49	209	21,196.78	455	91,497.21	74	7,002.41	201	1,646.13

Number and tonnage of sailing vessels, steam vessels, canal-boats, barges, &c.—Continued.

State and district.	Sailing vessels.		Steam vessels.		Canal-boats.		Barges.		Fishing vessels—			
									Over 20 tons.		Under 20 tons.	
	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.
NEW JERSEY.												
Newark	44	3,859.07	35	3,509.57								
Perth Amboy	289	14,491.05	48	8,197.90	1	278.69	48	14,047.00				
Little Egg Harbor	59	4,348.31	1	47.80					1	25.65	3	47.85
Great Egg Harbor	133	17,448.77	2	170.67								
Bridgeton	373	17,717.95	5	261.12								
Burlington	47	3,269.82	19	4,255.86								
Total	945	61,124.97	110	16,422.92	1	278.69	48	14,047.00	1	25.65	3	47.85
PENNSYLVANIA.												
Philadelphia	574	138,730.77	289	74,116.26	44	5,821.86	31	6,100.36				
DELAWARE.												
All Delaware	157	13,648.01	25	6,290.51								
MARYLAND.												
Baltimore	1,008	63,267.31	172	50,390.70			8	1,811.78	16	540.33		
Annapolis	162	3,248.93										
Eastern Maryland	816	20,046.39	2	106.12								
Total	1,986	86,562.63	174	50,496.82			8	1,811.78	16	540.33		
DISTRICT OF COLUMBIA.												
Georgetown	51	3,065.83	31	7,901.51								
VIRGINIA.												
Alexandria	74	5,386.28	14	566.17								
Tappahannock	128	3,151.15	2	91.73					4	128.68	25	256.18
Richmond	45	5,817.25	20	2,090.52								
Petersburg	1	6.81	4	210.48								
Yorktown	216	3,879.85	3	178.25								
Norfolk and Portsmouth	331	9,744.10	66	5,590.73								
Cherrystone	283	4,572.85	2	19.08					1	22.26	4	56.19
Total	1,078	32,558.29	111	8,746.96					5	150.94	29	312.37
NORTH CAROLINA.												
Albemarle	42	646.21	25	2,140.23								
Pamlico	101	2,104.23	17	1,123.02								
Beaufort	84	1,462.29	2	152.19					3	78.09	3	34.05
Wilmington	63	7,542.49	19	1,926.37								
Total	290	11,755.22	63	5,341.81					3	78.09	3	34.05
SOUTH CAROLINA.												
Georgetown	10	1,547.92	11	833.83								
Charleston	144	2,884.85	33	5,306.69								
Beaufort	17	1,060.67	6	409.01								
Total	171	5,492.74	50	6,549.53								
GEORGIA.												
Savannah	46	5,497.50	31	22,279.48								
Brunswick	38	9,898.84	12	932.90								
Saint Mary's	3	606.96	1	34.27								
Total	87	16,003.30	44	23,246.65								

Number and tonnage of sailing vessels, steamers, canal-boats, barges, &c.—Continued.

State and district.	Sailing vessels.		Steam vessels.		Canal-boats.		Barges.		Fishing vessels—			
									Over 20 tons.		Under 20 tons.	
	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.
FLORIDA.												
Fernandina	15	3,370.39	2	354.88								
Saint John's	12	522.05										
Saint Augustine	6	301.38										
Key West	139	2,680.40	12	3,316.82								
Saint Mark's	38	930.54	8	562.66								
Apalachicola	19	778.33	11	1,400.09								
Pensacola	126	14,335.49	19	2,316.31					9	368.39	4	46.14
Total	355	22,918.58	52	7,950.76					9	368.39	4	46.14
ALABAMA.												
Mobile	80	4,521.00	41	5,599.75					2	61.96		
MISSISSIPPI.												
Pearl River	119	4,296.53	12	918.68								
LOUISIANA.												
New Orleans	341	16,506.05	27	31,688.24								
Teche	70	1,688.69	33	1,829.25								
Total	411	18,194.74	60	33,517.49								
TEXAS.												
Galveston	151	4,749.56	33	2,953.79								
Saluria	29	547.60										
Corpus Christi	32	752.74	2	157.80								
Brazos de Santiago	12	458.32	4	518.65								
Total	224	6,508.22	39	3,630.17								
Grand Total	14,489	1,918,067.13	2,693	755,752.84	256	27,599.02	940	145,825.97				

*United States railroad communications on coast.**

Maine Central Railroad: From Vanceborough on New Brunswick frontier to Bangor, Belfast, steamer to Rockland, thence rail to Damariscotta, Bath, Brunswick, and Portland. There is a branch from Bangor to the coast at Bar Harbor. A local coast road from Machiasport to Whitney, on Machias River.

Boston and Maine Railroad: From Portland to Saco, Kennebunk, Portsmouth, Beverly, Salem, and Boston, with branch roads to the interior; a branch from Beverly to Gloucester and Rockport, Cape Ann.

Portland and Worcester Air Line: This road does not pass through the coast towns, but has connecting lines.

Old Colony Railroad: From Boston along bay shore to Plymouth; Boston to Tremont and the Cape Cod peninsula to Provincetown, with branches to New Bedford, Wood's Holl, and Hyannis from Yarmouth; Boston to Fall River and Newport, branches to New Bedford and Warren.

Shore Line: Boston, Providence, Wickford, Stonington, New London, New Haven, and New York.

*Travelers' Official Railway Guide, May, 1885.

New York and New England Railroad: Boston direct to Fishkill Landing on the Hudson River; Boston to Providence, to Norwich and New London; branch at Willimantic to New Haven; at Hartford with New York, New Haven and Hartford Railroad.

Boston and Albany Railroad: Westward from Boston.

Connecticut River Railroad: From New Haven north along the Connecticut River to Canada and the Northwest.

Long Island Railroad: From Brooklyn to Sag Harbor, on Gardiner's Bay, with a network of branches to all important places on Long Island.

New York City communications: New York Central and Hudson River Railroad, to the West; New York and Harlem, North; New York, New Haven and Hartford Railroad, to the East; New York City and Northern Railroad, North and East; New York and Greenwood Lake Railroad, unimportant; Pennsylvania Railroad, branches and connections South and West; Philadelphia and Reading Railroad, operating New Jersey Southern Railroad; New York, Susquehanna and Western Railroad, to Delaware Water Gap; New York, Lake Erie and Western Railroad, to Buffalo and West; New York, West Shore and Buffalo Railroad, to the West.

Philadelphia and Reading Railroad: Line to Long Branch and the adjacent coast of New Jersey; Southern Division from Port Monmouth, New York Bay, to Bay City, on the Delaware; branch to Tom's River; at Whiting, on New Jersey Southern Railroad, the Tuckerton Railroad to points on coast.

Camden and Atlantic Railroad: To Philadelphia from Atlantic City.

Philadelphia and Atlantic City Railroad: Parallel road with above.

West Jersey Railroad: To Atlantic City; also runs to Cape May.

Philadelphia, Wilmington and Baltimore Railroad: Operated by the Pennsylvania Railroad to all points West and South.

Baltimore and Ohio Railroad: New line to New York, and main line to the West from Baltimore and Washington; branch to Annapolis; connections Southwest.

New York, Philadelphia and Norfolk Railroad: Connects at Delmar with the Southern Division of the Philadelphia, Wilmington and Baltimore Railroad for Cape Charles, Virginia; on the Eastern Shore Peninsula, connecting branch roads terminate at Centreville, Oxford, and Cambridge, on the Chesapeake Bay, and run to the principal points on the peninsula and its coast.

Richmond and York River and Chesapeake Railroad:

Chesapeake and Ohio Railroad: To Newport News.

Seaboard and Roanoke Railroad: From Portsmouth, Va, to Weldon, Raleigh, and the Southwest.

Norfolk railroad connections: Norfolk and Petersburg; Norfolk and Virginia Beach; Norfolk and Southern Railroad via Elizabeth City to Edenton, N C., where steamers connect with Roanoke and Cashie River.

The Atlantic Coast Line Fast Mail Passenger Route is as follows:

Boston: New York and New England Railroad; Shore Line; Sound steamers;

New York: Pennsylvania Railroad; Baltimore, Philadelphia and Wilmington; Baltimore and Potomac or Baltimore and Ohio Railroad;

Washington: Alexandria and Fredericksburg Railroad.

Richmond: Richmond and Petersburg Railroad.

Petersburg: Via Petersburg Railroad; branch to Norfolk.

Weldon: Connects Seaboard and Roanoke Railroad.

Goldsborough: On Wilmington and Weldon Railroad; connects with Atlantic and North Carolina Railroad and North Carolina Division of Richmond and Danville Railroad to Morehead City via New Berne.

Wilmington: Wilmington, Columbia and Augusta Railroad to Florence; Northeastern Railroad to Charleston, S. C.

Charleston, S. C.: Charleston and Savannah Railroad has junction at Yemassee with Port Royal Railroad.

Savannah: Central Railroad of Georgia to Macon; by Savannah, Florida and Western Railroad to Way Cross—Thomasville and Chattahoochee River.

Jacksonville: Savannah, Florida and Western Railroad.

Saint Augustine: Jacksonville, Saint Augustine and Halifax River Railroad.

Tampa: Jacksonville, Tampa, and Key West Railroad, with branch road to Saint Augustine by Saint John's Railroad, and to Titusville, on Indian River.

Cedar Keys: Fernandina, by Florida Railway and Navigation Company.

Thomasville: From Way Cross via Savannah, Florida and Western Railroad.

Chattahoochee: Junction of Southern Florida and Western Railroad with the Florida Railway and Navigation Company; road from Jacksonville via Tallahassee.

Pensacola: Via Pensacola and Atlantic Railroad.

Mobile and New Orleans: Via Louisville and Nashville Railroad.

Houston: Galveston, Harrisburg and San Antonio; Southern Pacific Railroad.

Galveston: Galveston, Houston and Henderson Division of Southern Pacific Railroad.

San Antonio: Southern Pacific Railroad.

*Rolling stock of railways mentioned on coast.**

Name of road.	Locomotives.	Number of passenger cars.	Mail, baggage, and express cars.	Freight cars of 8 wheels.	Other cars.	Total number of passengers carried.	Total number of passengers carried for one mile.	Tons of freight carried.	Tons of freight carried one mile.
Maine Central	57	58	25	1,123	45	685,694	13,400,000	434,470	29,500,000
Boston and Maine	80	130	32	1,324	134	4,829,028	68,600,000	810,122	40,000,000
Portland and Rochester	7	9	3	142	12	115,836	2,100,000	105,817	100,000
Worcester, Nassau and Rochester	19	22	8	367	.....	371,019	6,800,000	467,479	15,000,000
Old Colony	109	288	55	1,928	5	5,526,279	89,500,000	1,371,449	51,200,000
New York and New England	87	119	30	1,588	272	3,121,057	41,800,000	968,549	43,700,000
New York, New Haven and Hartford	97	198	60	1,545	7	4,600,507	125,300,000	1,348,687	78,400,000
New York, Providence and Boston	27	31	13	250	16	859,843	22,200,000	303,186	11,300,000
Boston and Albany	248	187	48	5,055	655	5,993,287	113,200,000	3,310,539	375,500,000
Connecticut River	20	35	5	389	3	1,122,080	11,700,005	469,029	11,600,000
Long Island	53	209	18	346	10	6,228,292	58,000,000	320,837	10,500,000
New York Central and Hudson River	601	367	131	16,160	2,276	8,270,857	330,800,000	10,533,038	2,525,100,000
New York and Harlem	38	71	31	943	16	(†)	(†)	(†)	(†)
New York and Greenwood Lake	6	16	.....	40	20	326,264	4,900,000	93,937	.....
Pennsylvania	1,004	739	186	18,659	1,752	15,154,575	350,800,000	25,016,403	3,165,800,000
Philadelphia and Reading	448	367	44	12,049	7,846	9,822,422	132,800,000	12,636,105	834,400,000

* Railway statistics, Tenth Census, 1880.

† Included in New York Central and Hudson River.

Rolling stock of railways mentioned on coast—Continued.

Name of road.	Locomotives.	Number of passenger cars.	Mail, baggage, and express cars.	Freight cars of 8 wheels.	Other cars.	Total number of passengers carried.	Total number of passengers carried for one mile.	Tons of freight carried.	Tons of freight carried one mile.
New Jersey Southern	21	41	11	274	2	(*)	(*)	(*)	(*)
Central Railroad of New Jersey	282	222	74	1,992	.....	6,395,210	109,600,000	6,118,302	518,100,000
New York, Lake Erie and Western	539	314	97	20,512	219	5,491,431	180,500,000	8,715,892	1,721,100,000
Tuckerton	2	3	2	12	12	25,027	500,000	3,834	100,000
Camden and Atlantic	16	65	7	127	3	716,103	27,200,000	101,889	3,100,000
Philadelphia and Atlantic City	9	35	8	36	31	241,747	10,500,000	29,729	1,200,000
West Jersey	22	72	17	112	105	712,110	10,800,000	133,176	9,200,000
Philadelphia, Wilmington and Baltimore	78	131	48	1,302	15	2,705,827	71,700,000	1,222,694	67,400,000
Baltimore and Ohio	547	248	87	13,638	342	4,591,767	130,900,000	10,108,409	1,725,900,000
Baltimore and Potomac	25	47	6	266	3	895,965	13,300,000	347,455	8,400,000
Alexandria and Fredericksburg	4	7	2	21	.....	328,806	2,900,000	74,556	1,100,000
Richmond, Fredericksburg and Potomac	12	11	10	89	6	113,477	6,000,000	78,168	3,500,000
Richmond and Danville	40	20	15	714	40	141,531	8,700,000	370,442	41,300,000
Richmond and Petersburg	7	7	5	62	56	121,224	2,300,000	116,420	2,500,000
Richmond and York River	6	7	2	72	3	32,428	1,000,000	138,109	5,200,000
Petersburg	10	5	3	81	.....	30,305	1,500,000	69,395	3,500,000
Seaboard and Roanoke	17	9	2	286	.....	35,388	1,800,000	261,294	17,800,000
Chesapeake and Ohio	86	36	15	2,554	227	276,275	13,600,000	941,114	230,200,000
Wilmington and Weldon	25	23	10	350	20	93,671	5,600,000	157,911	10,900,000
Wilmington, Augusta and Columbia	25	12	6	327	.....	55,784	5,600,000	153,920	9,700,000
Atlantic and North Carolina	9	7	2	56	17	11,986	600,000	42,508	1,300,000
Port Royal and Augusta	11	7	3	180	6	5,636	400,000	117,967	7,400,000
Central Railroad of Georgia	82	38	47	1,100	48	75,148	500,000	637,897	1,000,000
Savannah, Florida and Western	26	24	21	334	62	169,845	7,700,000	310,679	33,900,000
Jacksonville, Pensacola and Mobile	11	13	6	52	41	28,969	1,000,000	70,000	400,000
Louisville and Nashville	140	73	34	3,238	74	646,434	34,600,000	1,508,745	221,900,000
Galveston, Harrisburg and San Antonio	24	17	14	1,100	24	71,226	5,300,000	168,056	23,600,000
Southern Pacific	48	75	14	915	243	410,757	13,500,000	203,080	12,900,000

* Included in Philadelphia and Reading.

The available shipping and railroad transportation are thus given in detail. Telegraph and telephone lines are so universally in use throughout the United States, and facilities for establishing such lines are so great, that in the event of war it may be presumed that all the exposed points are, or soon will be, in telegraphic communication.

The details of the highways, wagon-roads, &c., are not given; each minute portion of the coast has its own local roadways, and the consideration of each would involve a long and tedious review of the statistics of the census reports, too lengthy for the general purposes of this paper. Vehicles and draft animals are so abundant that they can be obtained for almost any exigency throughout the entire coast and frontier. And when a local lack of these exists, that would soon be remedied by the facilities of transportation as given in the preceding tables.

The Atlantic coast of New Jersey * offers no harbors or places available for the hostile operations of an enemy. Delaware Bay is large and commodious, but full of shoals. Twenty feet of water can be carried up to Chester and to Philadelphia. The river could, however, be easily obstructed. Fort Mifflin, its mortar battery, the Red Bank defenses, Fort Delaware, Finn's Point Battery and its mortar battery, fort oppo-

* United States Coast Survey charts.

site Fort Delaware and its mortar battery, constitute the defenses. These defenses and existing facilities for a torpedo defense are such that this bay and river need not be considered as one of the exposed points.

The Atlantic coast from Cape Henlopen to Cape Charles presents no harbors or bays with sufficient depth of water to be available as an exposed point.

The Chesapeake Bay is defended by Fort Monroe and Fort Wool. These are inadequate, as vessels could enter the bay and establish a base for hostile operations at any season of the year, and by so doing would sever communications via the inland coast navigation route, which if held intact would render any operations on our Atlantic coast from Massachusetts to Florida very difficult.

This inland coast navigation consists of the following lines of communication, viz:

Buzzard's Bay, Long Island Sound, New York Harbor, the Raritan River, Delaware and Raritan Canal from New Brunswick to Trenton and Bordentown on Delaware River, down the Delaware River to Delaware City, the Delaware and Chesapeake Canal via Elk River to Chesapeake Bay, the Chesapeake Bay to Norfolk, thence to Albemarle Sound by the Dismal Swamp Canal, or Albemarle and Chesapeake Canal, thence through Croatan Sound, Pamlico Sound, Neuse River, thence via Clubfoot Creek and New Berne and Beaufort Canal to Newport River and Beaufort, N. C.

There is a proposed extension of the inland navigation from Newport, on the Newport River, overland to White Oak River, through the waters of Bear Inlet, with cuts parallel with the beach connecting the inlets on the coast from Brown's Inlet to New River Inlet, to Stump Inlet, to New Topsail Inlet, to Topsail Inlet, Rich Inlet, Barren Inlet, to Masonborough Inlet, then a short cut from Masonborough to the Cape Fear River, below Wilmington, N. C.

From Smithville, N. C., on the Cape Fear River, to Georgetown, 67 miles, and from Georgetown to Charleston, S. C., 48 miles, the construction of canals would be quite feasible, utilizing Bull's Bay and connecting navigable waters. From Charleston to Savannah there is a natural inside water route, using Edisto Sound, Stono Inlet and connecting waters, Saint Helena Sound, Coosaw River, Beaufort River to Port Royal Roads, then the inside passage to the Tybee Roads

From Savannah River to Fernandina an inside passage is afforded by the various sounds and lagoons, as follows: Warsaw Sound, Ossabaw Sound, Saint Catherine's Sound, Sapelo Sound, Doboy Sound, Altamaha Sound, Saint Simon's Sound, Cumberland Sound, Saint Mary's River, and Nassau Sound.

The Atlantic coast line from the capes of the Chesapeake to Key West affords no very favorable sites for an enemy, except Port Royal Sound.

The occupation of this sound by an enemy would cut off the inland water route between Savannah and Charleston. The immense advantage of this most important harbor of the southern coast of the United States was of great service during the war of the Rebellion. There are no defenses at Port Royal, and as 21 feet of water can be carried over the bar it is navigable by large vessels, and would be very probably taken possession of by a formidable hostile fleet, which would there establish a safe base for hostile operations.

Although there is an absence of deep bays and harbors on the coast of the Southern States, such as have been described for the coast north of Cape Henry, yet the experience of the war of the rebellion demonstrates that vessels can anchor off of any part of that coast; and undefended inlets along the coast would be exposed to the attacks of a formidable blockading fleet, which would secure possession of some of these and interrupt the chain of inland navigation on the second coast line if it remained in present defenseless state.

The system of inland navigation is fed by numerous systems of navigation from the interior, and these would be of immense service to transport stores and material to re-enforce the second coast line.

These feeders may be detailed as follows:*

Long Island Sound: By the Thames River, Connecticut River, and Housatonic River.

New York Bay: By East River connecting to the Sound, Hudson River to Albany, Erie Canal to Buffalo; at Syracuse connects to Oswego Canal at Albany; connects with Lake Champlain Canal systems previously described. This route thus connecting the sea-coast inland navigation with the northern system from Chicago and Mississippi River.

Delaware and Raritan Canal: No feeders except connections.

Delaware River: None except its own waters.

Chesapeake Bay: The Susquehanna River, Patapsco, Potomac, York River, and James River. It has been proposed to established a central transportation route from the Ohio River at Point Pleasant via the Kanawha River, New River, Greenbrier River, and James River to Richmond and Chesapeake Bay.

The sounds of the coast are fed by their own waters and the rivers on the coast. A southern transportation route has been proposed to connect the Mississippi River to the seaboard by canals from the Tennessee River at Guntenville, Ala., to Coosa River, thence canal to the Chattahoochee River north of Atlanta, continuing to Macon on the Ocmulgee River to the Altamaha River on the coast.

These feeders to the inland sea-coast navigation are mentioned in the Thesis by Lieut. Tasker H. Bliss, First Artillery, in the following connection, viz: "Regarding the line above described (the inland coast route) as one along and within a front of operations, and the line of the Mississippi as a base, there are four grand routes existing wholly or in part that lead from one to the other. They may be classified and examined in order as: (1) the northern route, (2) the central route, (3) the southern route, (4) the Mississippi route."

The details of the operating canals are given in the following table. But in addition to the canals now operating others are proposed, and will in time be completed to perfect this system. At present additional facilities are being warmly advocated for the construction of a canal *via* the Choptank River, connecting the Chesapeake and Delaware Bays.

* Maps of Corps of Engineers, U. S. A., 1883.

Statistics of United States canals operated in the United States.

[Tenth Census, 1880, Vol. IV.—Transportation.]

Name and places connected.	Dates built and enlarged.	Length.		Width.		Depth.	Locks.				Cost.
		Canal.	Slackwater.	Surface.	Bottom.		Number.	Length.	Width.	Rise and fall.	
		Miles.	*Miles.*	*Feet.*	*Feet.*	*Feet.*					
Lake Superior Ship Canal	1868										
Lake Superior to Portage Lake	1873	2.12		100		14					$3,925,300
Saint Mary's Falls Canal	1853–'55	1.02		100		17	1	515	80	18	3,500,000
Illinois and Michigan Ship Canal											
Chicago to La Salle	1836–'48	102		60		6	15	110	18	141	*6,557,681
Ohio Canal and feeders											
Cleveland and Portsmouth	1825–'35	323		40	26	4	150	90	15	1,207	4,695,202
Miami and Erie—feeders											
Cincinnati and Toledo	1825–'35	284.25		50–60		5½	93	87–99	15	907	7,144,234
Erie—branches and feeders											
Albany to Buffalo	1817–'62	365.48	29.59	70	52½	7	72	110	18	656.46	51,609,200
Oswego Canal											
Syracuse to Oswego	1825–'62	18	20	70	56	7	18	110	18	155.55	3,077,429
Champlain—feeders and dam											
Whitehall to Waterford	1817–'70	81		58	44	6	33	110	18	179.5	2,378,910
Delaware and Hudson Canal Company											
Honesdale, Pa., to Rondout, N. Y	1826–'28	108	3	48	32	6	107	100	15	1,028	6,339,210
Delaware and Raritan Ship Canal											
Bordentown to New Brunswick	1834–'38	43		80		7	14	220	24	150	4,735,353
Delaware and Raritan—feeder											
Ball's Island to Trenton	1838	22		60		6	1	100	24		
Chesapeake and Delaware											
Delaware City to Chesapeake City		14		66		9	3	220	24	32	3,730,220
Albemarle and Chesapeake											
Norfolk to Currituck	1855–'60	13.94	30	80	60	7½	1	220	40	2	1,641,363
Dismal Swamp											
Elizabeth River and Pasquetank	1794	28	1	40–60		6	7	100	16½	35	1,151,000
Fairfield Canal											
Alligator River to Matteanmskeet Lake	1868	4.50		40		6					100,000
New Berne and Beaufort Canal Company											
Clubfoot Creek to Newport River	1880–'82	3		80		10					200,000
Augusta Canal											
Savannah River to Augusta	1847	9		150		11					1,500,500
Ogeechee Canal Company											
Savannah River to Ogeechee River	1829–'40	16		120		3	5				407,818
Santa Fé Canal Company, Florida											
Waldo and Melrose, Florida	1877–'80	10.50		35		5					70,000
New Orleans to Pontchartrain	1832–'35	6.5		85		7					1,000,000
New Orleans to Bayou Saint John	1794	2		60		7					750,000
Orleans Bank Canal	1832–'35	6.50		85		7					1,000,000
Harvey's Canal	1830	5.75		45		6	3	200	35		150,000
Tagliaferro Canal	1880–'81	1.75		30		4	2	110	20		40,000
Galveston and Brazos Navigation	1850–'51	8	30	50		3½					340,000

* Up to 1870.

III. The Gulf Coast and Mexican Frontier.*

The north coast of the Gulf of Mexico from Cape Sable to Rio Grande del Norte occupies a line of about 1,300 miles. The peninsula of Florida, forming the eastern shore of the Gulf of Mexico, is 275 miles, and 90 miles in average breadth. The surface is low, and innumerable lakes, swamps, and marshes abound. The coast line of the peninsula on both sides is indented with numerous bays, sounds, and lagoons, particularly along the Gulf coast, but they are generally shut in from the sea by keys, low sand spits, and coral reefs. The Florida Keys are an almost continuous chain of small islands, sand banks, reefs or keys extending southwest from Cape Florida for a distance of 220 miles. These reefs are very numerous and so surrounded by shoals that there is no passage between them for any vessels, except at Key West, where 12 feet of water can be carried in the north channel into Florida Bay.

These keys are of strategic importance in so far as they command the passage of the Straits of Florida, which is here 75 miles wide to the north coast of Cuba. For hostile operations or an offensive defense against Cuba the Florida Keys offer advantages to the United States, while they would be of importance if in possession of an enemy to control the outlet from the Gulf of Mexico.

Key West is the principal harbor and has several channels; 23 feet of water can be carried through the main ship channel, which is the best, and 30 feet through the southwest channel. The city of Key West contains cigar factories and sponge fisheries; but no valuable military resources. It is defended by Fort Taylor and batteries, and two martello towers, inadequate for its defense. Population, 9,000.

Charlotte Harbor is shallow and of no importance; 10 feet.

Dry Tortugas is a group of islets somewhat detached from the rest of the chain of Florida reefs and at their southwest extremity. There are 10 of these low islets which form a large, deep and commodious harbor. This admirable harbor is defended by Fort Jefferson, on Garden Key. If this harbor came into the possession of an enemy it would afford an excellent base for hostile naval operations, but an enemy would not find any resources except merely good anchorage and a place to rendezvous.

Florida Bay is between Florida and the north side of Florida Keys. It is of no strategic value.

The coast from Cape Sable, Cape Romano, Punta Rasa, passing Charlotte Harbor to Tampa Bay is indented with bays fit for small coasters but of no strategic value.

Tampa Bay is an extensive estuary from 6 to 10 miles wide, extending from Egmont Island in a north-northeast direction about 22 miles, where it forms two arms: Hillsborough Bay, 4 miles wide and 7 miles long north and south, and the western, Old Tampa Bay, 12 miles long southeast-northwest and six miles wide. Twenty-one feet can be carried round the east and north sides to a deep lane on west side. Anchorage in 4 or 5 fathoms. The town of Tampa, 720 population, is at the head of the bay. It is the terminus of the Jacksonville, Tampa and Key West Railroad. There is a proposed extension of the Florida Railway and Navigation Company from Wildwood to Tampa, which will give this bay additional importance Steamer line to Cedar Keys. No defenses, but the harbor has no great strategic value, except for operations in the immediate vicinity of local importance only.

* West India Pilot, Vol. I, pp. —, 1883; Lippincott's Geographical Dictionary; United States Coast Survey charts.

Cedar Keys are a cluster of small sandy and mangrove islets skirting a projection at the entrance of Waccasassa Bay. The town of Cedar Keys has 440 population. It is the present terminus of the Florida Railway and Navigation Company, and there is a line of steamers to Tampa and Key West. The place became of importance because of the establishment of rapid transit mail route to Havana via Key West for the United States. The entrance to the harbor is difficult, and it could easily be obstructed to prevent approach of enemy. There are no defenses and the place has no strategical value.

The Suwanee River discharges about 10 miles above the northwest point of Waccasassa Bay; there is but 5 feet of water over the bar at high water. This river is likely to become of great importance as the Gulf port of the Florida Ship Canal proposed to be constructed from the mouth of Nassau Harbor inlet or Fernandina, by connecting canal into deep water of the Saint John's River, up the Saint John's River to and through Doctor's Lake, thence by cut into the Suwanee River; thence into the Gulf of Mexico. The cutting between Doctor's Lake and the Suwanee River to be 61 miles, and that from Nassau Inlet into the Lower Saint John's 4 miles, a total canal length of 65 with 55 miles of deep river and lake navigation. The total length of the route thus proposed to be 120 miles. This canal is to be 200 feet wide and 30 feet deep. The harbor on the Atlantic will require but little work to make it of the requisite depth. The harbor at the mouth of the Suwanee River will require about $1,000,000. The estimated cost of this ship canal is from 20 to 25 millions of dollars, and the time required for its construction is about 3 years; 6,000,000 tons are estimated to pass through it in the first year, and 10,000,000 tons in the third year after completion.

Appalachee Bay is a small bight in the northeast corner of the Gulf of Mexico. It is but little visited, and is only a few feet deep at 10 miles from western shore and 5 miles from northern shore. Saint Mark's River empties into it from the north. It is the sea-port of Tallahassee, and the terminus of a branch of the Florida Central and Western Railroad. It is of no strategic or military importance.

Appalachicola Inlet is of considerable importance as the outlet of the Appalachicola or Chattahoochee River, which is navigable for a distance of 400 miles. Fifteen feet of water can be carried over the bar, and 4 feet up to the town. It is only accessible by very light draught vessels.

Saint Joseph's Bay is a large, deep, and commodious bay on the coast just north of Cape San Blas. It is very easy of access, excellent anchorage, and can be safely entered in a gale or a hurricane. The least depth at the entrance is 19 feet at low water, while within the bay the depth ranges from 25 to 33 feet. This bay is one of the very best on the Gulf coast. It is 25 miles long and 10 miles wide. The entrance, with over 18 feet of water, is about 1 mile wide; while the distance between the headlands, Saint Joseph's Point and Saint Andrew's Point, is about 8 miles, over any part of which 15 feet of water may be safely carried. It will in all probability become a very important commercial port when the country is developed, while its value as a naval base for an enemy is, or would be, not merely locally important, but may be used as a place to refit or rendezvous for operations elsewhere on the coast.

Saint Andrew's Bay is an irregular bay about 25 miles long, navigable for vessels

drawing less than 13 feet. It has three barred entrances. It is too shoal to be of any importance.

Pensacola Bay is an irregularly formed estuary stretching 20 miles inland northeast, and from 3 to 5 miles wide. It is protected by Santa Rosa Island, a remarkable sandy ridge not more than one-third of a mile broad and very low. Santa Rosa Sound is a deep, narrow passage north of the island. Nineteen and one-half feet of water can be carried into the bay. The city is 10 miles from the entrance, and the navy-yard but 3 miles. The harbor entrance is only seven-eighths of a mile wide. It is defended by Forts Pickens and McRee, and Fort Barrancas and redoubt on the north side. It is the best port on the north coast of the Gulf, though not as deep as Saint Joseph's Bay. It is the terminus of the Pensacola and Atlantic Railroad, and also of the Pensacola Branch of the Louisville and Nashville Railroad.

The navy-yard at Pensacola affords great facilities; but as the entrance to the bay is so well defended, it is not an exposed point, and hardly available for an enemy.

Mobile Bay is an estuary 30 miles long north and south. Just within the entrance on the east side there is a bight called Bon Secours Bay, 10 miles long and 10 miles wide. The Mobile River flows into the northwest corner of the bay, and it is navigable for steamboats for 53 miles. The entrance between Fort Morgan and Dauphin Island is 2¾ miles wide, but it is obstructed outside by Pelican and Saud Islands, 3 miles southward, and at 2 miles farther out by a narrow bar with 21 feet at low water. Eighteen feet of water can be carried through a dredged channel 21 miles long to the city of Mobile. Mobile is defended by Forts Morgan and Gaines, and the narrow dredged channel could be easily obstructed to prevent approach of an enemy. This port is therefore not likely to be easily taken possession of by an enemy; therefore, not an exposed point. There is a capacious floating dry-dock. The city has railroad communication by Alabama, Mobile and Ohio Railroad, Mobile, Alabama and Grand Trunk Railroad, Louisville and Nashville Railroad, and Mobile and Spring Hill Railroad. The population is about 40,000. It is the natural outlet of the greatest cotton region of the United States.

Mississippi Sound is contiguous to Mobile Bay, and is connected with it by Grant's Pass over shoals. It has only 5 feet of water. The sound is shallow, and only navigable by very light-draught craft. Its western limit is Lake Borgne, which is also very shallow, and connected with Lake Pontchartrain by the Rigolets. These waters form the "inland Gulf coast route." Lake Pontchartrain is connected by canal, as previously mentioned.

The Mississippi River is the most important river of North America and the longest in the world. The city of New Orleans is on its left bank, 120 miles from the sea. For 50 miles from the sea the river runs through a thin, ragged delta into the Gulf of Mexico, from which it is separated by embankments in several places only one-half mile wide. The extremity of the delta spreads like a fan into four prongs with very deep bights between, the extreme points being distant about 25 miles, through which this immense stream flows by 5 mouths, termed passes, named Southwest, South, Southeast, Northeast, and Loutre Pass. The South Pass is 26 feet deep and 300 feet wide, with a central depth of 30 feet without regard to width. Eads's jetties are

located at the entrance to this pass. This is the deepest and most important of the entrances to the Mississippi River. The Southwest Pass is 15 feet deep; the Southeast 7 feet deep. The Northeast Pass carries 9 feet in its south channel and 9½ feet in the north channel at low water. Loutre Pass is the northeasternmost, and has 12 feet of water in southern channel and 9½ feet in its northern channel at low water. Forts Jackson and Saint Philip are on opposite banks of the river at Plaquemine Bend, 70 miles below New Orleans. These are to serve as defense against approach of hostile fleet to capture New Orleans. These are adequate, and the transportation facilities of the great Mississippi River and the railroad facilities of New Orleans afford means for a formidable offensive defense of the Delta and neighboring waters, which are also defended by the following works, viz: Fort on Ship Island, Mississippi Sound; Fort Pike, Rigolets; Fort Macomb, at Chef Menteur Pass, which connects Lake Pontchartrain with Lake Borgne and the Gulf of Mexico; Tower Dupré, Lake Borgne; Battery Bienvenue, Lake Borgne; Tower at Proctorsville, Lake Borgne; and Fort Livingston, Barataria Bay.

These defenses are such that this vicinity need not be considered exposed. The only valuable base that could be established would be after the capture of the city of New Orleans, to effect which an enemy would have to contend against the vast resources of the great Western States of the Union.

Barataria Bay is an extensive lake, the entrance to which is at Fort Livingston, 35 miles from Southwest Pass of the Mississippi River. This lake communicates with Saint Denis and Grande Bayous, Little Lake, Bayou Perot, Lake Washa, and by canal to the Mississippi River at Carrollton, 10 miles above New Orleans. The whole distance is 110 miles, navigable for steamers of light draught and coasters.

Timballier Bay is 10 miles in extent east and west, and 8½ miles north and south; it is only navigable by light-draught steamboats and coasters.

Terre Bonne Bay is also very shallow. It is 4 miles long, east and west, north of Caillou Island.

Carlton Bay is situated between the west end of isle Dernière and the main land. Also shallow, but navigable for light-draught steamboats.

Atchafalaya Bay is about 18 miles wide and 10 miles deep. At the outer part of the bay there is 10 feet of water, but 7 or 8 feet only can be carried in narrow tortuous channels within the bay. The Atchafalaya River flows into the northeast corner. It is 250 miles long and navigable by river steamboats to its source. The New Orleans and Opelousas Railroad crosses this river at 10 miles from its mouth. This bay offers no advantages for an enemy's hostile operations.

Côte Blanche Bay and Vermillion Bay are two large shallow bights, west of Atchafalaya Bay. The interior of the bays has 5 to 9 feet of water, and the river emptying in the northwest corner is navigable by steamboat for 80 miles.

The coast from the southwest point of Vermillion Bay trends W. by S. ½ S. to Tiger Point for 12 miles, with a ridge of wooded land; thence 48 miles to the mouth of the Mermenteau River the shore is low and swampy. The Mermenteau is shallow and of no importance. Thence W. for 13 miles to coast is low, sandy, and barren to the Calcasieu River; of but little importance; the entrance is 1½ cables broad and depth only 5½ feet. The coast is of the same character to Sabine River.

The Sabine River flows about 500 miles, and it separates Louisiana and Texas. It is only navigable for river steamboats.

Galveston Bay is 30 miles deep from north to south, and from 6 to 15 miles broad. The San Jacinto River flows into the northwest corner and is navigable for 15 miles. Its entrance between Fort Point and Bolivar Point is 1¾ miles wide. Thirteen and one-fifth feet of water may be carried over the bar, rarely 14 feet. Jetties are to be constructed to deepen the channel of entrance to 25 feet. Nine and one-half feet of water can be carried to the city wharves. The defenses consist of earthen batteries on Fort Point and Bolivar Point to command the entrance. The city of Galveston is the most important of Texas. The railroads are the Gulf, Colorado and Santa Fé, International and Great Northern (South Pacific), and Texas and Mexican Railroad.

Galveston Island is 24 miles long and 1 to 2½ miles broad. The coast all along is clear, with 3 fathoms at 1 mile off until within 5 miles of the bar, when the 3-fathom line is 5 miles off. San Luis Pass is between the east end of the Oyster Bay peninsula and the southwest point of Galveston Island. There is but 8 feet of water over the bar of this pass. The opening is 9 cables wide.

Brazos River is a large stream about 900 miles long. It empties at about 38 miles from Galveston light. It is navigable to Columbia, a distance of 40 miles, and in rainy season to Washington, 300 miles distant, by light-draught river steamboats, &c. Only 6 feet of water on the bar. Texas and Pacific Railroad passes 4 miles from the coast. No defenses. No strategic importance.

The eastern coast, from Galveston to the Rio Grande, is clear, and has from 3 to 5 or 7 fathoms within 1 mile. The shore is low and has sand beach. San Bernard River is 8½ miles southwest of Brazos River. It is narrow, and has from 5 to 7 feet of water. The shore for about 5 miles to the westward is backed by the Cedar Lakes, which communicate with the sea at the west end. Cany Creek is 12 miles westward.

Matagorda Bay extends from a canal connecting with Cany Creek to Decharse Point, 44 miles long and of irregular extent, with Laracca Bay on its north and west sides. Indianola is a thriving place, second to Galveston in Texas.

The *Colorado River* empties into Matagorda Bay 2 miles west of the town of Matagorda. This river is 900 miles long, and is navigable by steamboats to Austin, a distance of 300 miles, except in summer.

San Antonio Bay, *Aransas Bay*, *Corpus Christi Bay*, and *Laguna del Madre* are a continuous chain of waters separated from the Gulf by the long, low, and extremely narrow chain of islands, viz, Matagorda, Saint Joseph's, Mustang, and Padre Island. These places are of no strategic value to an enemy, but very valuable for an offensive defense, as the bays are navigable by small craft, river steamboats, which no foreign foe could obtain to use against the country.

The waters and bays thus enumerated show the "second coast line" very plainly, and their navigation is constantly being improved, so that in the near future, with the development of the resources of the Gulf States, it is reasonable to suppose that this chain of waters will become of great importance. The clear shore line from Tiger Point to the Rio Grande, however, will permit an enemy to approach close enough to place the route under fire at many points along the beach. An enemy, however,

would labor under many disadvantages, and as the route would only be of great strategical value in case of war with Mexico, when it would be a feeder to our own base of operations on the Mexican frontier, it would scarcely serve as an important base for hostile operations against the United States.

The chain of inland Gulf coast navigation is, viz:

1. Laguna del Madre. Seven and one-half feet deep on the bar at the entrance, Brazos Santiago. The lagoon is only navigable by small river steamboats.

2. Corpus Christi Bay, contiguous and a northern part of the Laguna del Madre. Improvements are being made to have 12-foot channel through Aransas Pass up to the town of Corpus Christi.

3. Aransas Bay, also connected by the Aransas Pass, and to be improved for 12-foot channel to Rockport.

4. San Antonio Bay, contiguous and an extension of Aransas Bay. It is shallow like the other connecting lagoons.

5. Matagorda Bay, adjacent to Espiritu Santo Bay, which communicates with San Antonia Bay, and is a part of Matagorda Bay. The Paso Cavello Inlet is being improved for a 12-foot channel.

6. Incomplete. A canal is required from Cany Creek to Brazos River, a distance of 20 miles, 5 of which is occupied by the Cedar Lakes and San Bernard River; well adapted to facilitate the construction of this canal.

7. The Brazos Canal. This was dug out in 1850–'51, and was cleaned out in 1866–'67. It originally cost $340,000. It begins at the Galveston, Houston and Henderson Railroad bridge, southwest through Mud Island Pass from West Bay, then Follets Pass, southwest through Christmas Bay and the old Galveston and Brazos Canal to the Brazos River. The total distance is 38 miles. The canal proper is 8 miles, and the rest 30 miles of river, lake, and bay navigation. This opens an inland navigation for steamboats of 4-feet draught for about 150 miles.

8. From Galveston to Point Tiger there is no connected inland coast navigation. The projected route from Calcasieu River to Sabine Pass has been reported as not of public necessity.

9. Vermillion Bay.

10. Côte Blanche Bay.

11. Atchafalaya Bay and River.

12. Callon Bay.

13. Terrebonne Bay.

14. Timballier Bay to Bayou la Fourche.

15. Stretch to Barataria Bay of about 10 to 15 miles.

16. Barataria Bay, connecting by the Tagliaferro Canal.

17. Tagliaferro Canal, dug in 1880–'81, which is 1.75 miles long, 4 feet deep, still incomplete, and to connect with the Mississippi River.

18. Carondelet Canal, connecting Bayou Saint John with the Mississippi River.

19. Orleans Bank Canal, 6.5 miles long, to Lake Pontchartrain.

20. Lake Pontchartrain.

21. The Rigolets.

22. Lake Borgne.
23. Mississippi Sound.
24. Mobile Bay.
25. Mobile Bay outside, 10 miles not cut, requires canal.
26. Perdido Bay.
27. Perdido Bay outside, 2 miles not cut, requires canal.
28. Pensacola Bay.
29. Santa Rosa Bay.
30. Santa Rosa Bay outside, 20 miles, requires canal.
31. Saint Andreas Bay.
32. Saint Andreas Bay outside, 10 miles, requires canal.
33. Saint Joseph's Bay.
34. Saint Joseph's Bay outside, 10 miles, requires canal.
35. Appalachicola Bay.
36. Saint George's Canal.
37. Appalachee Bay.
38. Florida coast to the Suwanee River.
39. Florida ship canal (proposed) to Fernandina and thence to connect with the inland coast navigation of the Atlantic seaboard, as described in the preceding pages.

THE MEXICAN FRONTIER.

The boundary line between the United States and Mexico runs from the mouth of the Rio Grand del Norte along that river to the parallel of 31° 47′ N.; thence west for 100 miles along this parallel; thence south to latitude 31° 11′ N., whence it follows on that parallel to the 111th meridian. It then runs to the northwest to the Rio Colorado, which it crosses at 32° 29′ 45″ N.; then across to the Bay of San Diego, on the Pacific Ocean.

The Rio Grande del Norte, or Rio Bravo del Norte, rises in the southwestern part of Colorado, near 37° 40′ N., and 107° 30′ W. It traverses New Mexico southward and crosses the frontier into Mexico; it then runs southeastward from El Paso, a Mexican settlement 5 miles south of the boundary line, to the Gulf of Mexico. The river is about 1,800 miles long, but the volume of water is small in proportion to its length. It is shallow, and its navigation is obstructed by sand banks and rapids. Small steamboats can ascend the stream for a distance of 500 miles. The intersection of the river with the boundary line is 1,425 miles above its mouth, following the course of the stream. The region traversed by this river requires irrigation to render it fertile. The area drained by the river is almost 240,000 square miles. The only large affluent is the Rio Pecos.

The following is a list of the frontier towns and settlements, with their chief characteristics, viz:

American towns:

Brownsville, on the Rio Grande del Norte, 35 miles from its mouth. Population, 4,905. The Rio Grande Railroad connects it with Point Isabel on the Laguna del Madre, 22 miles. It has considerable river trade and commerce.

Hidalgo, a post village on the river, 57 miles above Brownsville.

Edingburg, a small village above Hidalgo.

Rio Grande City, a post village of 1,000 inhabitants, about 100 miles above Brownsville. Steamboats ascend to this town and beyond, but it is considered the head of navigation. No railroad communication. The Rio de San Juan, a Mexican river, joins the Rio Grande at this place.

Roma, a small post village 15 miles west of Rio Grande City.

Carrizo, a small post village about 230 miles from the mouth of the river.

Laredo, on the Rio Grande, about 300 miles from its mouth. A town of about 3,000 inhabitants; on the International and Great Northern Railroad of the Missouri Pacific Railway system, 154 miles by rail from San Antonio, and 1,100 miles from Saint Louis, Mo.; on the Northern Central Division of the Mexican National Railroad Company, 161 miles distant by rail from Corpus Christi. The Rio Grande and Pecos line to be completed up along the river to Eagle Pass, 115 miles; now operated as a coal road as far as Santa Tomas, 27 miles.

This road runs along the river as a frontier road as far as—

Eagle Pass, a town of 1,250 inhabitants, on the Rio Grande River. A branch of the Southern Pacific Railroad runs from Spofford Junction to Eagle Pass, distant 34 miles. It is opposite Piedras Negras, from which the Mexican International Railroad runs for 148 miles to Minclosa; this road is being extended. Eagle Pass is the proposed headquarters of the projected road—Texas, Topolobampo, and Pacific Railroad, which is to be a transcontinental road to the Gulf of California. None of it has as yet been constructed

Del Rio, a small village on the Southern Pacific Railroad Atlantic system, and also on the Rio Grande del Norte River. It is about 60 miles above Eagle Pass, and 500 miles from the mouth of the river.

Rio Pecos, the largest affluent of the Rio Grande del Norte, empties into the latter at a point near Painted Cave, about 50 miles above Del Rio. The Southern Pacific Railroad crosses this river and then goes up along the right bank of the Rio Pecos for a few miles and then goes over to El Paso. The river is 800 miles long; very shallow.

The *Rio Grande del Norte* makes a bend to the SSW., flowing through a mountainous country, and the railroad passes more directly to El Paso, meeting the river at a station called Rio Grande, 37 miles SE. of El Paso.

El Paso, a town on the Rio Grande del Norte, about 1,420 miles from its mouth. It is the junction of four railroads—Atchison, Topeka and Santa Fé Railroad, Mexican Central Railroad, connecting Kansas City with the city of Mexico. The Southern Pacific Railroad has a junction with the Texas and Pacific Railroad at Sierra Blanca, 92 miles east of El Paso. The latter branch runs to New Orleans, while the Galveston, Houston and Harrisburg Railroad forms the Atlantic system of the Southern Pacific Railroad.

The Southern Pacific Railroad diverges from the boundary line, which it meets again at Yuma on the Colorado River. The boundary line then runs due west on the 31° 47′ parallel of north latitude for a distance of 100 miles; it then bends at right angles due south for 36 miles, to latitude 31° 11′ north, on which parallel the line runs to the 111th meridian. The only point on this line is the small town of Nogales, the

terminus of the Sonora Railroad, which connects with the Southern Pacific Railroad at Benson by the New Mexico and Arizona Railroad, 88 miles long between Benson and Nogales. The road runs thence to Guaymas, on the Gulf of California, 265 miles from Nogales. The valuable mines of the State of Sonora, Mexico, and its excellent fruits, will render this frontier town of great importance. The excellent harbor of Guaymas is thus provided with good transportation facilities with the United States.

The boundary line then goes to the Colorado River, at Pedricks, in latitude 32° 29′ 45″ N.

The *Colorado River* rises in the Rocky Mountains, and flows to the Gulf of California through the Great Cañon of the Colorado. It is navigable for steamboats for the distance of 500 miles. The head of tide-water is about 50 miles from its mouth. Its length, exclusive of its branches, is 1,050 miles. It receives no tributary from the west side. The largest affluents are the Gila and Colorado Chiquito. The Colorado River forms a part of the boundary between United States and Mexico, from the town of Pedricks, in the southwest corner of Yuma County, Ariz., to Yuma, about 50 miles. From Yuma the line runs west to Initial Point, just below San Diego Bay, California.

Yuma is on the Colorado River at its junction with the Gila. A post village with about 2,000 inhabitants. Steamboats ascend the river up to and beyond Yuma. The river is spanned by a wooden railroad drawbridge on the Southern Pacific Railroad. The Southern Pacific Railroad runs through Yuma, and thence to Los Angeles, Cal., and up to San Francisco, with a branch of the California Southern Pacific to San Diego.

MEXICAN FRONTIER TOWNS.

Bagdad, at the mouth of the Rio Grande del Norte, ill-built and subject to overflow. Very small town at present.

Matamoros, a city of 20,000 inhabitants, opposite Brownsville, about 40 miles from the mouth of the Rio Grande. Exports specie, hides, and wool. Imports manufactured goods. Only accessible by light-draught vessels. A branch of the Mexican National Railroad from Matamoros to San Miguel along the right bank of the river, 74.5 miles. The main line of the New York, Texas and Mexican Railroad is to run south from Matamoros to Tuxpan, thence to the city of Mexico. A short line from city of Mexico to New York if completed.

Reynosa, a small town on the river and Mexican National Railroad, nearly opposite Edinburg.

Camargo, on the Rio de San Juan, 10 miles from the Rio Grande River at Rio Grande City. Population, 5,000. It is 180 miles E. by N. from Monterey. The Mexican National Railroad is to be extended to connect Monterey and Matamoros, passing through Camargo.

Laredo Nuevo, opposite Laredo on the Rio Grande River. It has a good interior trade, and is on the Mexican National Railroad. Northern Central Division to be extended to the city of Mexico; now in operation as far as El Salada, 323 miles south of Laredo Nuevo. The town has a population of about 2,000, and a good trade; exports hides, wool, corn, and beans.

El Paso Del Norte.—A settlement or a line of settlements on the right bank of the Rio Grande del Norte, with a population of about 5,000. The river is fordable near the town for a great portion of the year. The inhabitants are mostly half-breed Indians. It is the northern terminus of the Mexican Central Railroad, now in operation to the city of Mexico, the length of the railroad from the city of Mexico to El Paso del Norte being 1,970 miles. The construction of the northern and southern divisions has been effected since January 1, 1884, when a through-car system was inaugurated. There must be a bridge over the Rio Grande at this place, but it is not mentioned by any of the available authorities. The equipment of the road, according to the company's annual report, December 31, 1883, consisted of 94 locomotives, 66 passenger cars, 22 baggage, 2,121 freight cars. The development of the Mexican railroads has been progressing very rapidly of late and the amount of the rolling stock is at present much larger.

There are no other important towns along the boundary as far as Nogales on the Sonora Railroad. There is a road from Casito, above Hermosillo, on the Sonora Railroad, which crosses the boundary line at a point about 40 miles east of Nogales and leads up to the notorious Tombstone mining district and to the town of Tombstone, Ariz.

There are no places along the frontier worthy of further consideration up to the Colorado River, and none of any importance west of that or on the banks of that river.

The *Gulf of California* is or might become of value with the development of the resources of Mexico and its trade, and this is especially to be considered with reference to the advantages that it may offer for the landing of troops or a hostile force to cut the Southern Pacific Railroad. At present the advantages are all in favor of the United States. The border country of Mexico is very much behind in its development, though the fertile State of Sonora has natural advantages far superior to that of United States territory north of the boundary line.

There are no points along the frontier of any strategic value except where the railroads cross—at *Nogales, El Paso Del Norte, Laredo, Matamoros and Brownsville, and the Colorado River.*

With the city of Mexico as a base of operations, and Guaymas, on the Gulf of California, these points may, and probably would, be selected as the several places on the Mexican frontier from which hostile operations may be conducted on the part of the Mexicans.

IV. The Pacific Coast and Northwest Frontier.*

San Diego is situated on San Diego Bay, 15 miles north of the Mexican frontier. It has a population of 2,300. San Diego Bay forms an excellent harbor. It is, next after the harbor of San Francisco, the best on the coast. The port is formed by a bold projecting point of land on the west side, terminating at its southern extremity in Point Loma, and on the east side by low flat land called "The Island," which is really a low peninsula connected by a low narrow strip of sand beach to the mainland.

* Sailing Directions West Coast of North America, Imray; United States Coast Survey Charts; Report of Chief of Engineers United States Army; Traveler's Official Railway Guide for the United States, July, 1885.

between which strip the bar winds around and forms an indentation about 6 miles long and 2 miles wide in widest part. The entrance is over a bar over which 21 feet of water may be carried. This bar is about 600 yards across from the inner to the outer 5-fathom line. This port is growing in importance, and will undoubtedly become the site of a great commercial city. At present there are three towns on the bay—Old Town, National City, and New Town—with a combined population of 5,000. New Town is San Diego proper, while National City is the site of the railroad terminus. It is about 4 miles south of New Town, or San Diego proper. National City is the terminus of the California Southern Railroad, which runs from National City to San Diego, to Old Town, to Colton, 127 miles northwest of National City on the Southern Pacific Railroad, about 58 miles east of Los Angeles. A railroad is projected to be constructed to run due east from San Diego to Calabasas through the new Port Ysabel, at the head of the Gulf of California, to connect with the New Mexico, Arizona and Sonora Railroads to Guaymas. The only defenses consist of a fort on Ballast Point to command the entrance.

In view of the great range of modern ordnance and the depth of water close up to the sea-shore of the narrow peninsula which forms San Diego Bay, this bay would be entirely exposed to an enemy's fire.

The harbor would prove of great value if in the possession of an enemy for carrying on further operations on the coast and to raid and sever the several southern transcontinental railroads.

Newport Landing is 65 miles northwest of Point Loma, San Diego Bay. It is on Newport Bay, about one-half of a mile from the coast. The entrance to this small shallow bay is very narrow, through breakers on the bar, with but 4 feet of water in its narrow channel. A road leads to Santa Ana, which is at present the terminus of the Los Angeles and San Diego Railroad branch of the Southern Pacific Railroad. The road is projected and in the course of construction to Newport Landing, which is 40 miles southeast of Los Angeles.

San Pedro Bay.—This bay is formed on the west side by the high, bold land of Point Fermin, and on the east by the low coast of the main land. The new port of *Wilmington* has been built just around Point Fermin. This port is 22 miles south of Los Angeles. Harbor works have been instituted by the United States Government and the railroad company—the Wilmington Division of the Southern Division of Southern Pacific Railroad.

Originally there was but one foot of water when the improvement was begun, and now there are 10 feet of water. Vessels drawing 15 feet can readily enter at high water. The coasting trade passes entirely within the harbor. There is a jetty of 6,700 feet long, extending to Dead Man Island, under construction. This will form a ship channel. The total amount of the cost of the improvement by the Government will be $855,000. Population, 942; rapidly growing.

Los Angeles is the most populous town of Southern California, and is noted for the amenity of its climate, its fruits and gardens. It has become an important railroad center since the completion of the Southern Pacific Railroads. It has 4 railroads. Population in 1880 was 5,728; rapidly growing.

Monica Bay is between Point Vincente, the western end of San Pedro Hill, and Point Duma. On the northwest side of the bay, from Point Duma east, the mountains rise straight up from the coast. These mountains run east, and those from Point Lasuen, the southern extremity of San Pedro Bay, running about north and south from the valley of Los Angeles.

Santa Monica is a small town situated on the coast at the center of Horseshoe Bay. It is connected by the Los Angeles and Independence Railroad with Los Angeles, distant by rail 18 miles. A wharf 1,500 feet long has been built out from the shore, with 19 feet of water alongside of its outer extremity. It is a summer resort and bathing place. No defenses exist in all this vicinity.

Monica Bay is quite exposed, while San Pedro Bay is an excellent roadstead in spring, summer, and autumn, but exposed to the full force of severe winter gales.

San Pedro and Monica Bays may be considered as exposed points, and while they are not excellent harbors, yet, except in winter, they would form a desirable place for an enemy's hostile operations against Southern California, to which they are quite exposed. The destruction of the improvements and railroad facilities at Wilmington and Santa Monica would both be objective points for a hostile force.

Santa Barbara Channel is between the mainland and a number of islands south of Point Concepcion. The roadstead is open to all winds except these from the north. The depth at half a mile from the beach is 6 fathoms, and there are no sunken dangers in the kelp, which exists in some profusion along the shore.

The coast at Santa Barbara consists of a low, sandy beach, which is terminated by a bold bluff, named Point Costillo, on the west. The usual landing place is about half a mile east of Point Costillo. The town of Santa Barbara is about 90 miles west of Los Angeles. It is in the midst of a narrow, rich, agricultural district; a great stock-raising country; wood and provisions can be obtained; water with difficulty. There is no railroad communication; mountain roads to Los Angeles only.

The *Santa Barbara Islands* are eight in number, and lie opposite the shores of Southern California from Point Concepcion to opposite San Diego. These islands are as follows:

San Miguel.—The westernmost, 7½ miles long by 2½ miles wide, with deep water all round. Cuyler's Harbor is on the northeast side of the island, a small bay, with anchorage in 6 fathoms of water, and sheltered from all winds, except from the north, which rarely blows.

Santa Rosa.—Fifteen miles long and 10 miles wide; high and bold; no harbors exist around or on its shores.

Santa Cruz.—Almost due south of the town of Santa Barbara. It is the largest of these islands; 21 miles long and 4 miles wide. On the northern side there is a curve which forms Prisoner's Harbor, where good anchorage can be found in 15 fathoms; sandy bottom at a quarter of a mile from the beach. There is no shelter from heavy northwest swells following a northwest gale; sheltered from the southeast; deep water close to the shore. The island is 1,700 feet high.

Anacapa.—Strictly a group of three islands. The western island is 2 miles long by three-quarters of a mile wide, separated by only 10 feet from the middle island.

Boats can pass through the gap. The middle island is 2 miles long by 500 yards wide, and separated from the eastern island by a gap 200 yards wide, which is filled with rocks and impassable for boats. The eastern island is 1 mile long and 500 yards wide. The island consists of dark gray sandstone, which is rotten and crumbling. There is no harbor.

San Nicolas.—The most distant from the coast; 8 miles long by 3½ miles wide; very bold and steep; no landing place.

Santa Barbara is very small, with but 2 miles of coast line; steep shores and deep water all around.

Santa Catalina.—Seventeen and a half miles long and 4 miles wide at one end and 2 miles wide at northern end. Catalina Harbor on its west side at a depression in the island which forms a cove and anchorage on both sides; 3,000 feet high, with very deep water all around.

San Clemente.—West of San Diego about 60 miles; steep shores; very barren; with deep water, 36 to 120 fathoms close to shore.

These islands are not inhabited, and are of but little importance. They may, however, obtain strategic value in case of extensive operations against the coast, when they may serve as a base at Cuyler's and Prisoner's Harbors only.

San Luis Obispo Bay is open to the southward, and is a landing place at Port Harford for Pacific Coast steamers. There is a short railroad from Port Harford to Los Alanus, 64 miles distant; the road has no connection with other roads as yet; it is called the Pacific Coast Railroad, and is only local. The staple products are cattle, wool, hides, and cheese. Of no strategical importance.

Estero Bay, *San Simeon Bay*, and *Carmel Bay* are indentations along the coast, and do not form safe harbors, and they offer no advantages for hostile operations.

Monterey Bay is included between Point Pinos and Santa Cruz, 19⅜ miles apart, with a greatest indentation of 9⅜ miles at the mouth of the Salinas River. The southern part of the bay, close to the town of Monterey, affords the best anchorage in from 4 to 30 fathoms. The harbor is exposed to northerly winds, which, though generally prevailing, do not blow with sufficient violence to affect the safety of vessels anchored in the bay. There are no sunken dangers. The shores of the bay contain Monterey, with 1,112 inhabitants; Castroville, with 436 population; Pajaro; and Santa Cruz, in the northern part of the bay at Santa Cruz Harbor, containing 4,000 inhabitants. Railroads connect the settlements along the bay. The Southern Pacific Railroad of California, from San Francisco to San José; Gilroy to Pajaro, 99 miles; to Castroville, 110 miles; to Monterey, 125 miles. From Castroville the road branches to Soledad along the Salinas River. From Pajaro to Santa Cruz there is a branch 22 miles long by the bay shore. Santa Cruz is also the terminus of the South Pacific Coast Railroad from San Francisco via Oakland.

There are no defenses for the bay of Monterey, and if the harbor of San Francisco be adequately defended this bay would be of immense strategic value for operations against San Francisco. The bay is exposed to such an attack, and if an enemy be kept out of San Francisco this bay would be the objective point for the landing of an army for the invasion of the country, and in this case would be the base for hostile operations againt San Francisco.

Half-Moon Bay is an anchorage on the coast about 18 miles S. by E. from Golden Gate. The bay is open to the southward, from which quarter the most violent gales blow on the coast. The depth of water in the bay between the outer ledges of rock and the shore line is regular from 9 to 3 fathoms close up to the shore at less than a quarter of a mile. There are two wharves, one around Pillar Point and the other at Amesport Landing. There is a road, and only one, which crosses the peninsula of San Francisco. The highest part of this road crosses a depression in the peninsula between Laguna de Mercedes and Santa Cruz, at a place called Ridge, 1,093 feet above the ocean. This road may become of importance in the event of extensive hostile operations against San Francisco, when it would be of strategic value for the defense.

The Golden Gate and the immediate vicinity of San Francisco are omitted, as not pertaining to the subject considered in this paper.

Ballenas Bay is formed by a depression between the coast ridge and Table Mountain, inclosed by the Duxbury Point Reef, which runs out 1¼ miles SE. ¼ S. The bay is 3 miles wide ENE. from Duxbury Reef, and extends up 1¾ miles in-shore. From 4 to 8 fathoms are found in this bay, which affords shelter from northwest winds; exposed to the southward. It is, however, of no importance or strategic value.

Drake's Bay is formed by the curving shore line and Point Reyes, which curves back to SW., with a point running east. This bay affords excellent anchorage in heavy northwest gales, and, by anchoring close in north of Point Reyes, shelter from south gales, as the reef breaks the swell rolling in. There are several esteros or lagoons on the north side, but with very shallow entrances. Of no importance.

Tomales Bay extends from Tomales Point SE. ½ E. for 12½ miles, with an average width of seven-eighths of a mile. The entrance has but 10 feet of water, and the deep channel is very contracted. The swell from NW. frequently breaks over the bar. The shores of the bay are, however, becoming thickly settled, and with improvements it may become a very important place.

Bodejo Bay is a small bay on the coast above Tomales Point, with an interior bay separated from outer anchorage by a low, narrow strip of beach. The outer bay affords good anchorage in 3 to 5 fathoms. The inner bay is very shallow, and only fit for small coasters. It is of no importance.

The North Pacific Coast Railroad runs from Saucélito, opposite San Francisco, to Duncan Mills, 79 miles on the Russian River, 6 miles from the coast. This road passes the most important settlements of Tomales Bay and vicinity.

Fort Ross, *Haven Anchorage*, *Mendocino Bay*, and *Shelter Cover* afford anchorages for coast vessels in summer, but are dangerous in winter, and are of no strategic value for hostile operations.

Humboldt Bay is 270 miles north of San Francisco; it is 16 miles long and from three-quarters of a mile to 3 or 5 miles wide. The bar at the entrance is constantly changing. In the channel of the north spit not less than 3 fathoms can be carried. The towns of Bucksport, Eureka, Arcata, and Humboldt are on the shores of the bay, but these places are declining of late. The bay cannot be safely entered without a pilot, and it would afford no advantages for a hostile force.

Trinidad Bay is a very limited roadstead on the southeast side of the headland. It forms a moderately good summer anchorage, but is very dangerous in winter. It is of no strategic importance.

Crescent City Bay is one of the most dangerous of the roadsteads resorted to on the coast, but it has acquired importance on account of the town (Crescent City) being the depot for supplies for the gold-diggings on the Klamath, Trinity, and Salmon Rivers. No railroad communication.

Koos Bay, Oregon, is irregular in outline and shallow. It is the port for the lignite coal mines, which is, however, unfit for steamboat purposes, and is only used for stationary boilers and domestic purposes. It is shipped to San Francisco. There is no railroad communication. The coal mines may make it important if the coal found can be adapted for steaming purposes.

Umpquah River is the largest stream entering the Pacific between the Sacramento and Columbia Rivers The main stream and its south fork is about 100 miles long. Thirteen feet of water on the bar is the deepest part of the channel, 100 yards wide. The bar and channel are constantly shifting. Steamers ascend the river as far as Roseburg, on the Oregon and California Railroad. It is 197 miles from Portland, Oreg., by rail. The railroad is now completed to Ashland, 341 miles long. There are no defenses, and the place is of but little importance.

Yaquina River is small and unimportant. The little village of Newport is at its mouth.

Tilamook Bay has a narrow entrance, but expands into a long, wide bay, stretching to S.SE. From Cape Meares it is sheltered, but only 13 feet of water at low tide can be carried within. It is of very irregular depth and its tortuous channel very narrow. It is generally shallow and of little importance at present. No railroad communication with the interior.

Columbia River is the great and only line of river communication between the sea-coast and the interior of Oregon. It is 1,400 miles long, and navigable for a distance of 100 miles from its entrance by vessels drawing over 12 feet of water. Although it possesses at all times a good depth of water, it is so difficult and dangerous to enter that it can be said to possess but few advantages as a port. The channels of the entrance are subject to changes in width, depth, and direction. Of late years the south channel has been wider and deeper, occasionally reaching as much as 27 feet at low water, while the north channel has been decreasing in width and depth, yet carries about 21 feet. The cities of Portland, Kaloma, and Astoria are located on the river. The defenses consist of Fort Stevens, on Point Adams, and the earthen batteries of Fort Canby, on Cape Disappointment, on the north side. The river could easily be obstructed and a hostile force held in check.

Shoalwater Bay is full of shoals, as its name implies. It is 30 miles north and south, and its entrance is 5 miles wide between Leadbetter and Toke Point. The navigation is very intricate. Its channels are subject to frequent and irregular changes in width, depth, and direction. It may become a very important place in the future, but it is at present of no great importance. It is resorted to by oystermen. It affords no advantages for an enemy.

Gray Harbor extends 15 miles inland and covers an area of 150 square miles. The bar at its entrance shifts, and it is difficult for strangers to enter. More than nine-tenths of the harbor is bare at low water. The area of the surface of water bounded by these flats, bare at low tide, is only 4½ square miles. The harbor, however, may be used by a hostile force when the country is more thickly settled. It is defenseless at present, but not of sufficient importance for a base for hostile operations.

Strait of Juan de Fuca lies between latitude 48° 23′ N. and 48° 36′ N., on the meridian of 124° 45′ W. It is 13 miles between Cape Flattery and Bouilla Point, and it runs eastward as far as Whidby Island. The coasts are bold, abrupt, and covered with heavy growths of timber. They are remarkably free from dangers and may be approached to within one-half mile. The depth is 150 fathoms, but within 1½ miles from either shore it is generally under 40 fathoms.

Port Angeles is formed by a long, very narrow sand-spit, called Ediz Hook, which runs out for 3 miles E.NE. from the shore. The extremity is 1½ miles from the shore, and it thus forms an excellent and extensive harbor with from 9 to 30 fathoms of water. Coal has been found within 3 miles of the port. There is no railroad communication and no settlements of any size. It is defenseless, and may be used as a naval base for operations against the country when it becomes more thickly settled.

New Dungeness Bay is formed by the spit running out to Dungeness Point. It is sheltered and has good anchorage, in muddy bottom, in 5 to 10 fathoms. There is a small town. No railroad communication. It is undefended. It may be seized by a hostile force, especially if at war with England. The proximity to Victoria and Esquimault, the British naval depot, renders all of the ports and harbors exposed to their hostile depredations.

Washington Harbor entrance is nearly closed by a low sand-spit stretching across from east to west. A narrow channel exists with but 2 fathoms through it. The bay is a little over 1 mile wide and 3 miles long. It is deep, with 9 to 20 fathoms, over muddy bottom. It is quite an exposed point as not defended, though it could easily be defended and an enemy kept out by obstructing the bar.

Protection Island is about 7½ miles E. ¾ S. of Point Dungeness. It is 1¾ miles long, and very narrow, with low points at each end, with shoal water to the westward. It is about 200 feet high, covered with timber. It lies 2 miles directly off Port Discovery, and is admirably situated for the military protection of this port and vicinity. This is especially the case now with modern high-powered long-range ordnance. It is of great strategic importance.

Port Discovery has an average width of 1½ miles for 9 miles of its length to the Salmon River at its head. The great objection to this bay is its great depth—from 15 to 30 fathoms. The shores are bold and high, except near the head of the bay, where there is a little low land and the site of the town of Port Discovery. The bottom, however, affords excellent holding ground. This bay will become of importance with the development of the country, but there are so many others in the vicinity which have even greater value that it is somewhat neglected.

Puget Sound.—The entrance is through Admiralty Inlet between Port Wilson on the Quimper Peninsula and Admiralty Head on Whidby Island. This may be de-

cribed as an immense canal with an average width of 3½ miles for a distance of 60 miles. It then branches into a multitude of arms, which cover an area of 14 by 22 miles, comprising Puget Sound. At 16 miles from the entrance there is an inlet called Hood Canal, on the western side, which runs 60 miles S. by W., with an average width of 1½ miles; very deep, over 25 fathoms, and with numerous harbors and lights, with towns and settlements rapidly growing. This is also the case with the other arms of Puget Sound. The southern waters of Hood Canal are within 65 miles in a direct line from the Columbia River, and within 20 miles of the upper waters of Chehalis River, which empties into Gray Harbor on the Pacific coast. The importance of the close relations of the waters of Columbia River, Puget Sound, Shoalwater Bay, and Gray Harbor is manifest without entering into the details of the feasibility of connecting them by canals, &c. The Northern Pacific Railroad has a branch (Pacific Division) from Portland, Kalama, Winlock, Tenino, and Tacona to Seattle and Newcastle; the latter points are sites of valuable coal-mines. The Olympia and Chehalis Railroad runs from Tenino to Olympia. A branch road is projected to run from the main line of the Northern Pacific Railroad due west from Ainsworth to Tacoma and points on Puget Sound. The country is growing so rapidly since the completion of the Northern Pacific Railroad that the places cannot be described because of this growth. The entrance can be defended against hostile forces, but it must be considered as exposed at present. This region would be very valuable for a hostile force.

Port Townsend is a favorably situated harbor at the termination of the strait of Juan de Fuca at the outlet of the waters of Admiralty Inlet, Puget Sound, &c., and in proximity to the great inland waters of British Columbia. The harbor is 3⅝ miles wide between Wilson Point and Maronstone Point, and 7½ miles long to the southwest. The depth of water is very regular, and ranges from 8 to 15 fathoms, with soft muddy bottom inside Point Hudson. It is the site of the town of Port Townsend, which had 593 population in 1880, but is growing rapidly. The harbor would be of strategic value for operations against the country and in the great connecting waters of Admiralty Inlet and Puget Sound. As yet there is no railroad communication.

Deception Passage is between Whidby Island and Fidalgo, and is a narrow, dangerous passage communicating with Possession Sound and then with Puget Sound. This entrance is only fit for small boats and could easily be defended.

The Haro Archipelago is a group of islands between Vancouver Island and the United States, and belongs to the United States. The largest are San Juan, Lopez, Orcas, Theart, Waldron, Shaw, Blakely, and Decatur. These are only of local importance, and need not be considered in this paper.

Up to the Northwestern Boundary Point north from Fidalgo Island, there are several fine bays formed by the outlying islands and curved points of land. These are all exposed points on the frontier, and more particularly so since the advantage possessed by the Dominion and the British Government in the naval establishment at Esquimault.

The Canadian Pacific Railroad comes down to Frazier River and terminates at Port Moody. This road is but a few miles from the frontier, and in this part of this thinly settled country all the advantages would, in the event of war with England, be

in favor of the latter. The mere possession of the bays and harbors north of Whidby Island would be of but little advantage to an enemy, but they may approach by this route, and it would then be difficult to dislodge them.

Coal exists in this vicinity, and with the development of the country these places will become very important. The natural advantages of these bays and harbors will afford great facilities for trade and commerce.

On the northwest frontier the British have an advantage, as the terminus of the Canadian Pacific Railroad is so near the frontier, but to the eastward of the Rocky Mountains the Northern Pacific Railroad trends up to Lake Prescott and follows the boundary line much more closely than the Canadian Pacific does, and the Columbia River also gives some additional advantages in our favor.

Number and tonnage of vessels on Pacific coast June 30, 1884.

State and district.	Sailing vessels.		Steamers.		Total.	
	No.	Tons.	No.	Tons.	No.	Tons.
CALIFORNIA.						
San Diego	10	135.14	4	209.31	14	344.45
Wilmington	8	888.64	3	533.90	11	1,422.44
San Francisco	654	132,053.04	169	95,620.90	823	227,673.06
Humboldt	18	2,986.06	9	1,014.11	27	4,000.17
Total	690	136,062.88	185	97,377.34	875	223,440.22
OREGON.						
Southern Oregon	.....	.....	11	866.34	11	866.34
Yaquina	.....	.....	5	1,295.29	5	1,295.29
Oregon	27	1,780.02	30	2,107.43	57	3,887.45
Willamette	15	8,836.39	75	35,913.01	90	44,749.40
Total	42	10,616.41	121	40,182.07	163	50,798.48
WASHINGTON.						
Puget Sound	86	40,947.70	78	9,002.41	164	49,050.11
ALASKA.						
Alaska	17	349.82	2	130.53	19	480.35
Total Pacific coast	835	187,976.81	386	146,692.35	1,221	334,669.16

Rolling stock of railroads on Pacific coast, &c.

Name of railroad.	Locomotives.	Number of passenger cars.	Mail and baggage.	Freight cars of eight wheels.	Other cars.	Total number of passengers carried.	Number of passengers carried for one mile.	Tons of freight traffic.	Tons of freight carried one mile.
California Pacific Railroad	12	16	6	188	3	.....	.....	.....	.....
California Northern Railroad	2	2	1	13	2	10,998	274,616	12,118	157,534
Cascade Railroad	2	3	.....	48	18	7,954	51,701	100,478	627,977
Los Angeles and Independence	2	3	1	16	72	.....	.....	.....	.....
New Mexico and Southern Pacific	4	.....	.....	950	.....	.....	.....	.....	.....
Northern Pacific Railroad	64	29	15	1,610	216	161,193	13,548,646	278,255	67,490,069
Northern Pacific Coast Railroad	12	16	3	294	3	331,235	13,249,450	42,949	1,717,960
Oregon and California Railroad	12	11	4	261	10	101,972	3,259,335	54,266	5,077,950
Oregon Central	4	2	1	40	30	4,829	117,603	2,649	75,415
Oregon Railroad and Nevada Company	2	.....	.....	14	2	.....	.....	.....	.....
Salina and Southwestern	Rolling stock by Kansas Pacific.					3,090	63,068	17,975	371,918
San Francisco and Northern Pacific Railroad	7	9	3	259	24	93,790	4,312,627	48,284	2,406,89

Rolling stock of railroads on Pacific coast, &c.—Continued.

Name of railroad.	Locomotives.	Number of passenger cars.	Mail and baggage.	Freight cars of eight wheels.	Other cars.	Total number of passengers carried.	Number of passengers carried for one mile.	Tons of freight traffic.	Tons of freight carried one mile.
San Luis Obispo and Santa Maria Valley	2	1	.....	32	3	2,446	24,460	7,527	75,270
Santa Cruz and Felton	2	2	.....	40	3	.....	.....	.....	.....
Seattle and Walla Railroad	5	2	2	66	8	7,106	92,378	127,110	2,542,200
Southern Pacific Railroad	48	75	14	915	243	410,757	13,539,032	203,080	13,867,839
South Pacific Coast Railroad	10	33	7	255	71	654,448	9,253,977	105,353	3,132,234
Union Pacific Railroad	178	124	41	3,081	139	217,050	100,151,148	992,881	436,154,439
Central Pacific Railroad	226	266	56	4,643	663	6,669,037	180,779,711	1,829,755	449,580,783
Wal'a Walla and Colorado River	6	3	1	71	10	12,588	438,548	72,149	2,478,854
Western Oregon	3	2	1	65	.....	19,141	557,194	28,991	1,273,103
Willamette Railroad	2	.....	.....	16	.....	1,528	22,920	22,389	335,835
Kansas Pacific	105	54	23	1,702	31	280,228	35,874,444	723,973	157,423,148
Santa Cruz Railroad	3	3	1	32	7	20,421	379,137	13,584	225,942

These statistics point out the means for the transportation of the troops on the coast and how the exposed points which may be threatened can be protected.

The most important of the exposed defenseless points on the whole frontier and coast are as follows:

The Lake shores: By the construction of Welland Canal and improvements in Saint Lawrence River navigation.

Lake Champlain: By the Dominion canals and Montreal's railway communications.

The Maine frontier: At Eastport, Calais, &c.

The several bays on the Maine coast.

Provincetown Harbor; Cape Cod Bay.

Gardiner's Bay: The most desirable for a possible base of hostile operations.

The seaboard entrances to the inland coast navigation at Delaware Bay, Chesapeake Bay, and inlets along the Carolinas and southern coasts.

Port Royal Roads; Key West and Dry Tortugas; Tampa Bay; Suwanee River and Florida Ship Canal; Saint Joseph's Bay.

The Mississippi River and its connections with the Gulf Coast inland navigation.

On the Mexican frontier the four points: Brownsville, Laredo, El Paso, and Nogales, and the Colorado River's mouth in the Gulf of California.

On the Pacific coast there are San Pedro and Monica Bays; Monterey Bay; Port Angeles in the Straits of Juan de Fuca and New Dungeness Bay; Protection Island, Port Townsend, and Puget Sound.

W. H. BEEHLER,
Lieutenant, U. S. N., Staff Intelligence Officer.

Approved:
R. P. RODGERS,
Lieutenant, U. S. N., and Chief Intelligence Officer.

REPORT OF THE COMMITTEE TO COLLECT INFORMATION AND REPORT UPON THE CAPACITY OF THE COUNTRY TO FURNISH ARMOR AND GUNS, AND THE STEPS NECESSARY TO ENLARGE THAT CAPACITY.

COMMITTEE No. 4.

Mr. Joseph Morgan, jr., of Pennsylvania, Chairman.
Mr. Erastus Corning.
Lieut. Col. Henry L. Abbot, Corps of Engineers, U. S. A.
Capt. Charles S. Smith, Ordnance Department, U. S. A.

Hon. Wm. C. Endicott,
Secretary of War, Chairman of Fortification Board:

The Committee to collect information and report upon the capacity of the country to furnish armor and guns, and the steps necessary to enlarge the same, have the honor to report as follows:

SYNOPSIS OF DATA, ETC.

A.—Present capacity of the country to produce steel.
- (1) Quantity of steel made.
- (2) Kinds and quality of steel made and ores to make.
- (3) Present forging capacity.

B.—What are the demands for armament. (Number wanted, weight each, total weight.)
- (1) For Army guns; Navy guns. Grand total weight of guns.
- (2) Army: Armor, turrets, casemates. Navy: Armor ships. Grand total weight of armor.
- (3) Size of gun forgings wanted.
- (4) Size of armor forgings wanted.

C.—How to increase capacity of this country to meet our wants.
- (1) Guns: Plants needed to forge; plants needed to finish.
- (2) Armor: Plants needed to forge or roll; plant needed to finish.
- (3) How to get plants for guns, and for armor.

A 1.—Quantity of steel made.

Information as to production of iron and steel, 1884.

Country.	Coal.	Iron ore.	Pig-iron.	Bessemer steel.	Open-hearth steel.	Crucible steel.	Rolled iron.
	Gross tons.	*Gross tons.*	*Gross tons.*	*Gross tons.*	*Gross tons.*	*Gross tons.*	*Gross tons.*
Great Britain	160, 757, 815	16, 500, 000 and 2, 728, 672 Imp.	7, 528, 866 total. 2, 530, 461 Bessemer.* 166, 822 Spiegel.*	1, 299, 676	461, 965	100, 000	2, 237, 585
United States	99, 851, 807	7, 639, 581 and 487, 820 Imp.	4, 097, 867 total. 30, 261 Spiegel.*	1, 375, 531	117, 515	58, 269	1, 747, 595
	Met. tons.	*Met. tons.*	*Met. tons.*	*Met. tons.*			
Germany and Luxembourg, 1883.	70, 442, 648	8, 756, 617 and 800, 373 Imp.	3, 572, 115	1, 060, 591 all kinds.	.....	.....	1, 571, 409
France	20, 127, 209	1, 412, 710 Imp.	1, 855, 247	364, 058	121, 922	7, 158	877, 836
Belgium	18, 041, 000 and 1, 254, 000 Imp.	1, 487, 748 Imp.	738, 105	179, 803 all kinds.	.....	.....	468, 185
Austria and Hungary, 1883.	17, 047, 961	.....	701, 037	271, 783 all kinds.	.....	.....	288, 649
Russia, 1883	3, 742, 380	.....	498, 400	225, 140 all kinds.	.....	.....	291, 800

*Included in total.

From the foregoing table we see the United States is second in production of coal, pig-iron, manufactured iron, and steel, and first in production of Bessemer steel, with a production of steel of all kinds very little less than Great Britain, and that we produce 21 per cent. of the pig, 27 per cent. of the steel, and 25 per cent. of the coal production of the world. We undoubtedly have all the natural advantages to make ourselves fully as independent of other nations in the supply of guns and armor as we are in the supply of railroad material.

A 2.—Kinds and quality of steel made and ores to make.

The quality of steel made in the United States varies from the finest crucible and open-hearth to ordinary Bessemer grade. At present the best steel for *ordnance* and *armor* is that manufactured by the open-hearth process. The open-hearth is best adapted for making large ingots with least cost. Crucible steel is used only by a few makers, while Bessemer steel is not so uniform as open-hearth, nor can the large quantities of uniform and well-mixed metal be brought ready for casting so easily by this process as by the open-hearth. The *stock* should be as free as possible from phosphorus and sulphur, and it is therefore limited to selected Swedish pig or bar, the pig from carefully selected ores, or dephosphorized metal. As to our own ores we quote from Swank's pamphlet on iron ores:

"If the question were asked whether this country could, if required, supply from within its own borders all of the iron ore needed in every branch of its iron and steel industries, including the manufacture of the finer kinds of crucible steel, the answer might be unhesitatingly made in the affirmative. We can make as good iron for crucible steel as the Swedes do if we would only be as painstaking as they are. We have ores in great abundance for the manufacture of Bessemer steel by the original

or acid process" (and for the basic, or Thomas, process). "These ores are, however, not readily accessible to all the Bessemer establishments of the country. We have discovered ores for the manufacture of spiegeleisen and ferro-manganese that would place our steel industry on a self-sustaining basis if our foreign supply of these products should be interrupted. We would be better off in this particular than Great Britain, which is practically without manganiferous iron-ore deposits. Manganese itself we export to that country."

"Foreign ores obtained in Spain, Italy, and other countries are yearly imported into many States to be used either alone or as a mixture with native ores, and the reasons for this importation are, first, their excellence for special purposes, particularly the manufacture of Bessemer pig-iron and spiegeleisen; and, second, their cheapness as compared with native ores that must be transported long distances by rail. We do not, however, import annually one-fifth as much foreign ore as Great Britain, nor one-half as much as France or Belgium, and but little more than one-half as much as Germany. Our imports of iron ore in 1884 amounted to only one-sixteenth of the total quantity of domestic ore consumed in that year."

By using a moderately pure pig from home materials, which is afterward dephosphorized by puddling or similar process, material of the utmost purity can be had at moderate cost. In proof of this we cite the practice of washing pig at the Cambria Works, from cupola metal, containing phosphorus .357 per cent., from which were made—

Washed heats..... .....Nos..	271	272	273	274	275	276	277
Per cent. phosphorus.....	.037	.023	.019	.028	.034	.024	.022

The example shows what may be done with a metal originally containing three times as much phosphorus as is admissible in rail steel, and that nine-tenths of the phosphorus can be eliminated, making a grade nearly pure enough for ordnance. It is therefore a matter of choice and close calculation of cost whether to buy pure foreign or domestic ores and make pig, buy foreign pig, or use entirely materials of moderate cost, and dephosphorize, but in event of foreign war it would be as important to be able to use our own ores as to be able to make and cast our own gun ingots or forge and finish them. It will give us the greatest security and strongest defense to develop all our own resources, and the Board might recommend such a policy to Congress.

A 3.—Present forging capacity.

As to our *present forging capacity*, we refer to Gun Foundry Board Report, page 3:

"With a view to such experiments as their appropriations would justify, the Ordnance Bureaus of the War and Navy Departments have from time to time addressed the steel manufacturers of the country on the subject of furnishing steel for cannon, but thus far have met with only partial success. The reasons for this will be noticed farther on in this report, but the fact is here stated to emphasize the conclusion that the immense steel works of the United States, from lack of demand for this special

material, have not the necessary plant for forging, and are in no condition at present to manufacture steel for cannon in such quantities and in such sizes as are essential for a suitable armament for the country."

This Committee finds the above is the correct statement of facts.

We have ample capacity for manufacturing steel of proper quality, but lack the means of forging in pieces of large size, say for guns of 8 inches diameter and upwards.

DEMANDS FOR ARMAMENT.

B 1.—*Number of guns and mortars proposed for coast defense by the Armament Board*, 1884.

[Copy from Capt. Edward Maguire.]

Port.	Guns.				Mortars.
	16″	12″	10″	8″	12″
Portland, Me	.....	20	20	.....	48
Portsmouth	.....	10	.....	10	.....
Boston	8	28	20	10	96
Newport	.....	20	.....	20	48
Willets Point	6	10	20	10	48
Narrows	8	30	20	10	96
Sandy Hook	4	30	20	.....	.....
Philadelphia	.....	20	10	10	32
Baltimore	.....	10	10	.....	16
Washington	.....	20	10	10	16
Hampton Roads	6	18	20	.....	16
Charleston	.....	10	5	10	.....
Savannah	.....	10	.....	10	.....
Mobile	.....	10	.....	10	.....
New Orleans	8	20	.....	10	.....
San Francisco	10	40	71	5	96
Total	50	306	226	125	512

RECAPITULATION.

Number of guns.	Bore.	Weight of each.	Total weight.
	″	*Tons.*	*Tons.*
125	8	13	1,625
226	10	25	5,650
306	12	48	14,688
50	16	114	5,700
707	Total weight		27,663

Not including mortars enumerated in above report.

Compare with Report of Chief of Engineers for 1884 (pages 58–59), guns for New York, Philadelphia, Boston, and Baltimore, are:

Number of guns.	Bore.	Weight of each.	Total weight.
	″	*Tons.*	*Tons.*
22	16	114	2,508
55	12	48	2,640
65	10	25	1,625
142			6,773

Also Report of Chief of Engineers for 1884 (pages 62–63), guns for Portland, Newport, Hampton Roads, New Orleans, and San Francisco, are:

Number of guns.	Bore.	Weight of each.	Total weight.
	"	*Tons.*	*Tons.*
16	16	114	1,824
80	12	48	3,840
135	10	25	3,375
231			9,039

Not enumerated in Report of Chief of Engineers are Portsmouth, Washington, Charleston, Savannah, and Mobile:

Number of guns.	Bore.	Weight of each.	Total weight.
	"	*Tons.*	*Tons.*
60	12	48	2,880
15	10	25	375
50	8	13	650
125			3,905

Total from Report of Chief of Engineers.

Number of guns.	Bore.	Weight of each.	Total weight.
	"	*Tons.*	*Tons.*
38	16	114	4,332
135	12	48	6,480
200	10	25	5,000
373			15,812

We are of the opinion that the nine first-named ports are those most important and necessary to be armed

The estimate in Gun Foundry Board Report, page 50, on plant, is for an annual capacity—

Number of guns.	Bore.	Weight of each.	Total weight.
	"	*Tons.*	*Tons.*
50	6	5	250
17	12	44	748
12	16	114	1,368
79			2,366

or a total of 79 guns, and total weight of 2,366 tons.

At rate of Gun Foundry Board estimate it would take from 6 to 10 years to arm these 9 first named of our principal sea-ports. In addition to Army guns there will be needed, some for Navy, say 700 tons 6 inch to 16 inch guns per annum; in Gun Foundry Board Supplemental Report, page 114, war need of Navy is estimated as 2,000 guns of various calibers.

B 2.—Of armor required.

As per Report of Chief of Engineers for 1884 (pages 58, 59, 62, 63).

Army estimates, for ports of New York, Philadelphia, Boston, and Baltimore, 9 turrets, 55 casemates; and for ports of Portland, Newport, Hampton Roads, New Orleans, and San Francisco, 10 turrets, 10 casemates.

Total.	Weight of each.	Total weight.
	Tons.	*Tons.*
Turrets, 19	785	7,065
Casemates, 65	195	12,675
	Total	19,740

Weight of turrets and casemates from letter of General Abbot, June 8, 1885.

Navy estimates, as per memorandum of Admiral Simpson, June 7, 1885. Armor per annum, 3,800 tons weight.

Summary for 10 *years.*

	Heavy guns.	Armor.
	Tons.	*Tons.*
Fortifications	16,000	20,000
Navy	7,000	38,000
Total	23,000	58,000

Or a total of 81,000 tons of heavy steel forgings.

Steel for projectiles and for smaller guns not considered in above quantities.

B 3.—Size of forgings for guns of present designs.

[Maximum measurements.]

	Army.			Navy.		
	Length.	Outer diameter.	Weight.	Length.	Outer diameter.	Weight.
	′ ″	″	*Tons.*	′ ″	″	*Tons.*
8-inch gun tube	20 7.5	17	4.59	21 7	17.3	5.37
Jacket	8 7.75	23.75	3.75	9 5	25.6	4.81
Ring	1 4.25	30.25	.59	1 10	31	.91
10-inch gun tube	27 4.2	19.95	8.54	27 2	20.3	8.95
Jacket	11 3.25	27.95	6.65	12 9	31.7	10.35
Ring	1 4.25	39.75	.83	3 3.3	41	3.16
12-inch gun tube	32 10	23.85	14.51	34 8.25	23.5	14.76
Jacket	13 6.5	35.75	11.28	15 7	38	18.22
Ring	1 11.25	48.25	1.77	3 0	49	4.04
16-inch gun tube	43 9	29.25	25.27	41 10	33.2	33.04
Jacket	18 11	40.25	21.16	20 1	48.75	38.74
Ring	3 8	66.75	5.30	3 4	56	3.91

Or the range of sizes is as in the table below.

	Length.	Bore rough.	Diameter rough.	Weight rough turned.
	′ ″	″	″	*Tons.*
Tube:				
Minimum 8-inch...	20 7.5	7.75	17	4.59
Maximum 16-inch..	43 9	15.75	29.25	25.27
Jacket:				
Minimum 8-inch...	8 7.75	.....	23.75	3.75
Maximum 16-inch..	20 1	.....	43.75	33.74
Ring:				
Minimum 8-inch...	1 4.25	.....	30.25	.59
Maximum 16-inch..	3 4	.....	56	3.91

B 4.—*As to armor sizes* the greatest practicable weight is best, say 50 tons weight per plate, and 22″ x 10′ x 10′ for maximum dimensions.

C.—How shall we increase our capacity.

In providing guns and armor for our national defense two distinct and well-marked lines of policy may be followed: *First*, we may buy abroad from factories already established, both guns and armor, ready finished for our ships and forts; or, *second*, we may provide our own manufactories in this country.

The quantity of material required and amount of money to be expended in purchase of material are so large that no one who investigates the subject can decide in favor of the first course, or foreign purchase, which will develop the skill and resources and nourish establishments and people who are possible enemies. It is of as much importance to avoid a line of policy that will strengthen our enemies' attack as it is to build up our own defense. We understand that Congress and the nation have decided against this course, and in favor of the second line of policy or home development. The advantages of this, if followed out only to the limited extent indicated in the report of the Gun Foundry Board, are that we shall gain experience in the manufacture of the material, we will know the stock required, how to manipulate it and what machinery is necessary, and we shall have at least the skeleton establishments and organizations, which may be expanded to any extent hereafter if needed.

Following out the line of policy of home development to the utmost will be best for the nation, and as far as possible the manufacture should be restricted to domestic ores and metals; the machinery should be of our own manufacture and design, and the management and capital should be our own.

Taking it, then, as settled by all the considerations which compel us to provide a national defense, that our best defense is a policy which shall develop our own capacity, the question is, How large a plant or plants shall we build to start with, and who shall build them?

We need, as above shown, large quantities of guns and armor, and to manufacture this large plants must be built The committee thinks for guns the smallest plant worth considering should be of capacity marked out by Foundry Board, page 50, report already quoted, or casting and forging capacity for guns should be equal to

about 2,000 tons roughed turned material. It will take two such plants ten years to supply our Army and Navy with 580 heavy guns 12″ and 16″, and 1,000 lighter guns, 6″ or other sizes. To produce the ingots the casting capacity of existing open-hearth plants is capable of ready enlargement, but forging capacity does not now exist, and to provide it requires a large investment. (See estimate Gun Foundry Board Report, page 50.)

The finishing capacity for guns also requires large investment for plant (see estimate Gun Foundry Board Report, pages 50 and 98), say of $2,000,000.

Additional forging or rolling capacity will be needed for armor, but if steel armor is adopted the same casting capacity will do, as the gun-forging plants of the size given by the Gun Foundry Board will not be able to use all the ingot capacity of the plant necessary to make gun ingots.

With the immense metallurgical resources of this country it is only for us to develop those resources to produce the material we want, which we have shown must be great in quantity, of superior quality, and require costly machinery to produce.

As to the method of this development the Committee are of the opinion that the plan proposed by the Gun Foundry Board *in the original report*, page 48, is the best, viz: The Government should offer to manufacturers a contract for a sufficient amount of material to enable some one or more concerns to embark in the business of furnishing the material for guns, roughed turned and bored. The report says:

"The Board is thus led to the conclusion that it is not advisable to embark in the establishment of a gun foundry, properly so called, but that it is more judicious to establish gun factories, and to purchase the material from our manufacturers. At present the steel manufacturers of our country are not prepared to produce the material required for the larger calibers, and the important question arises, What means shall be adopted to induce them to study the subject and embark in the manufacture on a large scale? They cannot be expected to do this at a sacrifice of their own interests. This object can only be achieved by holding out a fair prospect of ultimate remuneration for the expenditures necessary to undertake the work, and this can only be done by the action of Congress. If, then, Congress shall conclude to arm the country, it will be necessary that a sum of money shall be fixed as a permanent yearly appropriation to be expended for this purpose, the amount to be assigned proportionally between the War and Navy Departments. With such a guarantee against loss the Board is satisfied that the required material for cannon will be forthcoming from our own steel works. It would not be necessary for the Government to be associated with a large number of firms for the supply of its material, for it is probable that the private establishments that would take up the subject would only be those with large available funds, which they would be willing to put into a special plant, and for remuneration on which they would be willing to wait a reasonable time. The permanent appropriation would give them surety of ultimate profit, the only condition being success in providing the material that would be indicated in their contracts. From personal intercourse with some of the leading manufacturers the Board is led to believe that the plan will have the effect of guiding the private industries of the country to the aid of the Government in developing this work of national importance."

And from the Supplementary Report (page 98):

"The question whether the fabrication can be better and more economically performed in Government establishments, or by private contract, or by a combined system, has been carefully considered, and the Board has been unable to discover any reason to modify the unanimous opinion expressed in its report of February 16, 1884, 'that it is more judicious to establish gun factories'; that there should be 'two gun factories under the control of the Government,' and 'that the Army and Navy should be provided with separate establishments.'"

The Board repeats its unanimous opinion "that the steel manufacturers should be called upon to provide the material."

In determining the foregoing the committee consider that the following details, which determine the gun plants, are settled. The guns must be high-powered breech-loading rifles, of steel of high quality, forged by hydraulic pressure, and built up by carefully shrinking together the machined pieces. The experience of all nations has crystallized into this practice for high-powered guns, and it is likely further progress will be in the direction of larger and longer guns, and the better quality of material and workmanship which comes with experience. These points were all fully considered by the Gun Foundry Board, and their report provides for the manufacture of such guns.

Some of the shells for naval combats and *coast defense will also be of forged steel.*

In reference to armor plate, experience is less decisive and the course to follow is not so plain. It is not fully marked out, although alluded to by the Foundry Board. In view of the great success of the 19″ Creusot steel plates at Spezia, on trials of last October, where soft steel plates gave results better than compound plates of iron and steel, and because of the great cost and waste of the wrought iron plate manufacture in making compound iron and steel plates, and with little hope of further advance in the iron plate manufacture, it seems to us all progress is limited to steel armor and that a compound plate of hard and soft steel will soon be made surpassing the all-soft steel plates. Such a steel plate, if of large size, can be better worked under a powerful forging press than by a roll train. The large steel plates of Creusot could not be better worked except under a hammer or press.

To the steel casting and forging plants, therefore, we must look for future armor plates, and this would point out the need of still greater forging capacity than that needed to make our guns. Much of the work, viz, casting, forging, annealing, and tempering, done upon both guns and armor requires the same apparatus, but if we want armor the forging plants must be increased in capacity.

STEEL CASTINGS.

The mounting of the large guns and many of the details of the turrets of land defenses will require tough and reliable steel castings. These may with safety be left to the competition of the steel-casting manufacturers now in the market. Castings of 15 to 20 tons weight each can now be made in quantities, and a demand for larger castings will be met either by an increase of the capacity of present works or by the castings made by the gun ingot plant, which will not have work to the full extent of its casting capacity on gun and armor ingots.

IRON ARMOR PLATES.

The plates used in 1861 to 1865 were made on old and small mills, yet even at that time plates 12 feet by 4 feet by 1 foot were rolled. There are now four large plate mills, viz, Park, Spang, Springfield, and Otis, fitted up for making large steel ship and boiler plates, but which, in the opinion of the committee, are quite capable of rolling iron plates 7 feet by 12 feet by 9 inches thick, and possibly larger. And the larger blooming trains of some of the steel works are also capable of rolling large plates. The Cambria new mill will reduce a plate pile from 18 inches to 6 inches thick, and has ample power and convenient tables to handle a large pile. We believe there will be no difficulty in procuring a taker for a large contract to roll soft armor plate of 6 inches to 9 inches thickness, 6 to 8 feet width, 12 to 20 feet length, among the existing mills.

Respectfully submitted.

JOS. MORGAN, JR.,
Chairman.

NEW YORK, *July* 13, 1885.

MEMORANDUM.

NEW FORGING PRESS FOR CHARLES CAMMELL & CO., *now* (*July*, 1885) *building by Davy Brothers, Sheffield.*

Two cylinders, 35″ diameter worked up to 2 tons pressure per square inch, or about 4,000 tons total (1,963 square inches x 2 tons). The construction allows ingots 10 feet high and 10 feet wide to be worked between the dies of the press. There are 2 traveling cranes, each capable of handling 150 tons. The height of the press requires the cranes to clear 60 feet above the floor level.

The total cost is £250,000 for press, pumps, buildings, furnaces, cranes, etc.

The use of this press is supposed to be the forging of steel armor. About one-half the weight of the above-named press is of steel. The four vertical posts are steel forgings. The four cross girders carrying the cylinders weigh 200 tons and are steel castings. The press is operated by rotative steam pumps, not geared. The exhaust water is returned to a large wrought-iron receiver, in which a sufficient air pressure is maintained to insure the receiving valves of the pumps opening promptly.

The estimate of Davy Brothers is that a 2,000-ton press will fully equal in forging capacity a steam hammer of 100 tons.

At Sheffield a large forging press has also been built by Vickers in their own shops. John Brown & Co. are also being supplied by Tannett & Walker with large press.

[Extract Percy's Metallurgy, French edition, 1867.]

MANUFACTURE OF ARMOR PLATES.

The manufacture of iron plates for the protection of coast batteries and war ships exposed to artillery fire, which every day is getting more perfect, has recently been considerably developed. In spite of trials made in the United States to make the armor of plates of slight thickness, simply laid on top of each other, they have in

Europe continued to use one single plate, varying in thickness from 0.10 meter to 0.18 meter, and in weight from 1 to 12 tons. The plates most commonly used are from 0.10 to 0.13 meter in thickness, and under ordinary circumstances will resist cast-iron projectiles from ordnance of 0.165 meter and 0.208 meter caliber, but for cylindrical projectiles of steel this thickness is not sufficient. Some Russian and English armored frigates also carry 0.15 meter on the most exposed points. The Americans who use guns throwing projectiles of 200 to 300 kilograms have manufactured for their monitors and rams armor of 0.20 meter in thickness, which in its order will become ineffective against projectiles of 500 kilograms. To give an idea of the importance of this new manufacture, created by the requirements of the military marine, the fact will suffice that in the frigate La Gloire, which is entirely covered with plates of 0.1 meter and 0.12 meter, the weight of the metallic armor alone is 840,000 kilograms. In the English frigates Prince Consort, Royal Oak, Royal Albert, &c., the weight of the armor varies from 1,000 to 1,400 tons. According to the tests which the armor of vessels or forts have been submitted to, the iron best adapted seems to be that which is possessed of sufficient hardness to resist penetration, and of a tenacity great enough to prevent tearing to pieces or breaking under the rough and violent shock of the balls. The most serious drawback of our armor is, in fact, its brittleness. The partial exfoliation or the destruction of the welds between the fibers is not a matter of immediate danger, but the cracks penetrating from one side of the plate to the other create an imminent danger, especially in the face of a rain of projectiles rapidly succeeding each other on the same points. At first it was considered necessary to use superior charcoal pig for obtaining at the same time very tough and very strong metal. In fact, the plates made from charcoal pigs from Sweden, Corsica, and Styria have generally satisfactorily stood the tests; but it was an exaggeration to consider the exclusive use of charcoal pig as a necessity for the manufacture of armor of good quality. The works placed in the first rank for the quality of their products do not hesitate to use a mixture of superior coke and charcoal pigs in varying proportions. It may be said that the superiority of their products depends on the nature of their mixtures. Very good plates seem likewise to have been obtained from unmixed coke iron. The armor plates are made under hammer or rolled. They are generally composed of two slabs, one on each side, and of interior part or body inclosed between the slabs. The bars which serve for the first piles are 0.02 meter to 0.04 meter in thickness. The slabs and the body of the armor plate are manufactured separately and then piled, welded, and stretched. Three works in France have entered upon the manufacture of armor, those of M. E. Charrière, at Allevard; the works of Messrs. Marrel Frères, at Rive-de-Gier; and La Compagnie Petin et Gaudet, at St. Chamond. In 1864 the latter of these works, by far the most important, did not make anything but rolled plates; Messrs. Marrel, on the other hand, delivered hammered plates. We will here only describe these two works.

MARREL ARMOR.

In 1864 the works of Messrs. Marrel comprised, besides furnaces and hammers for making shafting, &c., for the navy, 6 heating furnaces and 7 hammers of from 3 to 12 tons; the hammers of 10 and 12 tons serving for hammering out the slabs and the

finished plates; one 20-ton hammer for plates of exceptional dimensions, annealing furnaces, planers and boring machines, &c., and one hydraulic press of 1,200 tons for bending the armor plates. With these appliances the works could deliver 500 tons of plates per month.

The iron used comes from the "Usine de l'Horme." The hematites from La Voulte, Ardèche, are rather rich in silica. Treated with hot blast and with an excess of flux, they produce a gray iron of good quality, which is broken, mixed with charcoal pig, and carefully puddled into fibrous iron. The puddled bars are cut, piled, reheated, and rolled into finished bars. These bars, which are cut 2.50 meters long, have their longitudinal edges beveled in order to make it possible, when finally piling, to pack them together without leaving empty spaces. It is estimated that the bars cost about 32 francs per 100 kilograms. The piles for the slabs are composed of these bars, the edges of which are first welded by heating slightly and striking them a few blows with the hammer, so as to hold the bars in place. One half of the pile is then subjected to a first heating and stretched, then a second heat and stretched again, in order to give the plate the required dimensions, say the width of the plate for 0.10 meter thickness. The other half is then treated in the same way in two heats. The plate is hammered on edge and on the flat, care being taken not to open the welds and to forge from the center toward the edges, so as to save the fiber of the iron. The pile, when worked in this manner, is divided into two, and each half serves for a slab for one plate. The body of the plate is composed of three layers of bars hooked into each other and held together by two sheets of iron. It is rolled.

The final pile is worked as the pile for the slabs; that is to say, it is hammered in four heats, one-half at a time. The heating furnaces have natural draft, and are provided with vertical boilers. The piles are placed on edge in the furnace and afterward hammered from the center toward the end. Sometimes the forged metal shows blisters, which are ascribed to the production of gases or to slag remaining between the layers of the pile. These blisters are pierced with a steel point, and the blistered part is hammered anew to weld it strongly. The forging of one plate requires fifteen men, for manipulating the hammer and the huge tongs and for the furnaces and cranes. As the plate is from 5 to 6 meters long, it is cut through the middle, and thus two ordinary plates obtained. The loss from sawing and shearing amounts to about one-tenth of the total weight.

One next proceeds to the tempering, the object of which is to give toughness to the plates, which have been made too hard by the working of the rolls. The plates are heated red in a special furnace and then simply dropped into a ditch filled with water. The annealing, which follows this tempering, likewise takes place in a special furnace, where the plates are heated dark red and left to cool slowly for five or six hours.

The annealed plates are then finished, planed on the edges, drilled, and straightened, according to the shape demanded by the naval constructors. This last operation is done cold by the hydraulic press. It is certain that the texture of the iron is not sensibly changed by this straightening, but it is difficult to state that the same is the case for sharp bends. It might perhaps be preferable to work the iron hot, but this

would likewise alter the quality of texture, and would be more inconvenient. The iron in the Marrel plates is mixed, granular, and fibrous, having both strength and softness. The grain is caused, it is stated, by the many successive reheatings. The expenses of this manufacture are about the following: First, the total quantity of puddled bars used for one ton of planed and bored plates is estimated to be one ton and one-half. The difference of 50 per cent. is represented by the loss in the furnace, 25 per cent.; scrap, which is afterward utilized in other manufactures, 15 to 18 per cent.; the remainder filings and borings. Besides, it is calculated that one-tenth of the armor-plates are rejected. The rejected plates are utilized for making slabs, but are only estimated at a rate of one-half or, highest, three-quarters of their value. The fuel consumed at Rive-de-Gier amounts to 2.5 to 3 times the weight of the plates. It costs at the works 12 francs to 14 francs per ton. The net cost per ton of plates is thus:

	Francs.
1,500 kilograms puddle bars, plates, and flats, at 370 francs per 1,000 kilograms	480
3,000 kilograms coal, at 13 francs per 1,000 kilograms	39
Labor for forging	27
Labor for tempering, annealing, boring, and bending	40
	586
Rejection of one-tenth at the shop, calculated at one-half of full value	29.30
	615.30
Deduct value of scrap, 18 per cent., at 200 francs per 1,000 kilograms	36
	579.30
General expenses, repairs, superintendence, and interest, amounting to 100 per cent. of manual labor	67
Total net price	646.30

The market price at works has been successively 1,175, 975, and 925 francs, which still ought to leave a profit on the manufacture of 280 francs per ton. But this figure has been considerably reduced in consequence of defects in the manufacture, accidents, extra expenses, rejections, &c. Then there are required for armoring a vessel, besides the slightly bent plates, a certain number of V-shaped armors for the stern and the point of the stem, which require a very long and very expensive hammering. As the number of these plates is comparatively small, they have been delivered in lots sold to the Navy at the same price as the ordinary plates. But as their net cost is a great deal higher, they reduce in proportion the profit on the ordinary manufacture.

NOTE.—These works in 1885 are making compound plates. The hammering operations had been abandoned and all work was done by rolling.—J. M., jr.

ARMOR PLATES FROM PETIN, GAUDET & CO.

The manufacture of armor at the works at St. Chamond is, as we have stated, carried on with the aid of a rolling mill. The slabs are made separately and banded together with the interior layers of the pile. The pile is composed of bars cut diagonally at both ends, 80 to 100 millimeters wide, 20 to 25 millimeters thick, placed so that the joints are horizontal or oblique. In order to reduce still more the possibility of bad welds, the bars are arranged diagonally and alternately each way. Thus the

joints of each layer are parallel to each other, but at right angles with the joints in the layers next above and below. The piles are exposed to a first moderate heat, and pass five or six times through the rolls, so as to weld before they are exposed to the full heat. The furnaces have artificial draft. The piles are placed in them on the flat. Tongs 6 to 7 meters long, of a peculiar construction, are used for handling the metal. The lower shank of the tongs has two prongs, the upper shank only one, which can be drawn back from or approached to the pile by a guide motion, regulated by the rotation of a pinion with rack and lever. In consequence of the rapid wear the parts of the tongs which enter the furnace to seize the pile are of heavy dimensions. The tongs are suspended from a hook and chain, the upper part of which is fastened to a truck running on a railroad. It is easily understood that the difference between the arms of the lever in regard to the point of suspension close to the pile makes it feasible to handle very heavy pieces with little effort and few men. One pair of tongs are placed in front of and one behind the mill, so that armor plates of 4,000 to 5,000 kilograms can be readily rolled, which with ordinary appliances would require a great deal of manual labor and cause loss of time and objectionable reduction of temperature.

For rolling plates of a constant width and of same thickness all over, and with the long sides sufficiently smooth not to require shearing, have been adopted the improvements constituting the universal mill, such as it has been previously described. See also the description of the mill for alternative motion, page 377. Thanks to this apparatus, only the ends of the plates need be cut. One end is cut on the circular saw, the other in a planer, or the plate may be heated a second time in order to saw it. When one end is sawed the plate has changed from dark red to reddish black; it is then tempered as already indicated.

The power calculated for an armor-plate mill is 300 to 400 horse power. The horizontal engine at St. Chamond has link motion for distribution and reversing and runs 60 revolutions per minute. The diameter of the fly-wheel is 7 meters; the rim weighs 7,000 kilograms. Owing to their low speed and consequent chilling, old mills made entirely of cast and wrought iron are liable to a great many breakdowns. To reduce the number of passes to 20 and at the same time make pieces of great dimensions, the fixed and moving parts of an armor-plate mill ought to possess an enormous resisting power. Rolls (7,000 to 8,000 kilograms) and housings (about 11,000 kilograms), which, even when made of wrought iron, have not been able to resist the strains caused by breakage. Couplings, pinions, shaftings, and fly-wheels, have also, for greater safety, been made of cast steel. The steel castings are of the same dimensions as the rejected cast-iron ones.

The plate-mill at St. Chamond as thus equipped lasted for several years without giving cause for repairs; at the same time easily rolling 50 tons of armor a day.

The most of the plates of Messrs. Petin & Gaudet have a granular texture. They have been subjected to experiments in different countries, showing a remarkable superiority and are justly considered amongst the best made in Europe. If it cannot be said that all the iron entering into their composition is made out of all charcoal from Corsica and other localities, still it is certain that the color of their fracture is lighter

than that of plates from Marrel, Brown, &c., a circumstance which seems to indicate that the quality of the product depends rather on the choice and judicious mixture of materials than on any special process of manufacture, mainly the rolling. In fact, it is difficult to give an opinion about the greater advantage of either of the two methods of manufacture, both of which have furnished excellent plates. The method of hammering offers, it is true, a greater simplicity in regard to appliances, and is perhaps more economical, as the mill alone requires a motor of 200 to 300 horse-power for ordinary size plates, and in consequence a considerable and continued manufacture. The mill has the advantage of having capacity to satisfy large demands rapidly.

NOTE.—The St. Chamond works in 1885 were making compound armor. The mill and methods of making iron armor are substantially as here described.

APPENDIX A.

LIST OF STEEL WORKS AS REPORTED TO AUGUST, 1885, TO AMERICAN IRON AND STEEL ASSOCIATION.

BESSEMER STEEL WORKS.

NOTE.—The ton used in giving the capacity of the converters is the ton of 2,240 pounds. For a full description of these works see the list of rolling mills.

MASSACHUSETTS—1.

Worcester Steel Works, Worcester. Two 4-ton converters. Made their first blow June 2, 1884.

NEW YORK—1.

Albany and Rensselaer Iron and Steel Company, Troy. Two 7-ton converters. Made its first blow February 15, 1865.

PENNSYLVANIA—9, AND 2 BUILDING.

Bethlehem Iron Company, Bethlehem. Four 7-ton converters. Made its first blow October 4, 1873, and the first steel rail October 18, 1873.

Cambria Iron and Steel Works, Cambria Iron Company, Johnstown. Office, 218 South Fourth street, Philadelphia. Two 6½-ton converters. Made its first blow July 10, 1871.

Edgar Thomson Steel Works, Carnegie Brothers & Co., Limited, Bessemer Station, Allegheny County. Office at Pittsburgh. Three 10-ton converters. Made their first blow August 25, 1875, and the first steel rail September 1, 1875.

Lackawanna Iron and Steel Works, Lackawanna Iron and Steel Company, Scranton. Two 5-ton converters. Made its first blow October 23, 1875, and the first steel rail December 29, 1875.

Oliver Brothers & Phillips, Pittsburgh. One 2-ton Clapp-and-Griffith stationary converter. First blow made March 25, 1884.

Pennsylvania Steel Works, Pennsylvania Steel Company, Steelton post-office. Office, 208 South Fourth street, Philadelphia. Two 7-ton and three 8-ton converters. Made its first blow in June, 1867.

Pittsburgh Bessemer Steel Company, Limited, Pittsburgh. Two 4-ton converters Made its first blow March 19, 1881, and its first steel rail August 9, 1881.

Pittsburgh Steel Casting Company, Pittsburgh. One 5-ton converter. Made its first blow August 26, 1881.

Scranton Steel Company, Scranton. Two 4-ton converters. Made its first blow March 29, 1883, and its first steel rail May 4, 1883.

American Iron and Steel Works, Jones & Laughlins, Pittsburgh. Building. Works to contain two 7-ton converters.

Juniata Iron and Steel Works, Shoenberger & Co., Pittsburgh. Building. Works to contain one 7-ton converter.

WEST VIRGINIA—1 COMPLETED AND 1 BUILDING.

Riverside Iron Works, Wheeling. Two 5-ton converters. Made their first blow June 11, 1884.

Wheeling Steel Works, Wheeling. Building. Works to contain two 5-ton converters.

OHIO—3, AND 1 BUILDING.

Bellaire Nail Works, Bellaire. Two 4-ton converters. Made their first blow April 28, 1884.

Cleveland Rolling Mill Company, Cleveland. Two 10-ton converters. Made its first blow October 15, 1868.

Otis Iron and Steel Company, Cleveland. One 5-ton converter, built in 1884.

Laughlin Junction Steel Company, Mingo Junction. Building. Works to contain two 5-ton converters.

ILLINOIS—4.

Joliet Steel Works, Joliet Steel Company, Joliet. Office, Honore Building, Chicago. Two 8-ton converters. Made its first blow January 26, 1873, and the first steel rail March 15, 1873.

North Chicago Rolling Mill Company, 17 Metropolitan Block, Chicago. Two 6-ton converters. Made its first blow April 10, 1872.

North Chicago Rolling Mill Company, South Chicago. Office, 17 Metropolitan Block, Chicago. Three 10-ton converters. Made its first blow June 14, 1882.

Union Steel Company, 38 Portland Block, Chicago. Two 6-ton converters. Made its first blow July 26, 1871.

MISSOURI—1.

Saint Louis Ore and Steel Company, E. A. Hitchcock, Receiver, Singer Building, Saint Louis. Two 7-ton converters. Made its first blow September 1, 1876.

COLORADO—1.

Colorado Coal and Iron Company, South Pueblo. Two 5-ton converters. Made its first blow April 11, 1882.

UNITED STATES.

Total number of Bessemer steel works: 21 completed and 4 building. Number of converters: 46 completed and 7 building. Total annual capacity of the completed works, 2,490,000 net tons of ingots.

OPEN-HEARTH STEEL WORKS.

NOTE.—These works are fully described in the list of rolling mills. The ton here used is the ton of 2,240 pounds.

NEW HAMPSHIRE—1.

Nashua Iron and Steel Company, Nashua. One 10-ton Siemens furnace.

MASSACHUSETTS—3.

Bay State Iron Company, Boston. One 6-ton Siemens furnace. Not in operation for several years.

Norway Steel and Iron Company, 23 Mason Building, Boston. Three 10-ton Siemens furnaces.

Worcester Steel Works, Worcester. One 10-ton Siemens furnace.

NEW YORK—1.

Johnson (Isaac G.) & Co., Spuyten Duyvil. One 8-ton open-hearth furnace.

NEW JERSEY—1.

Newark Steel Works, Benjamin Atha & Co., Newark. One 7-ton Siemens furnace.

PENNSYLVANIA—17 COMPLETED AND 2 BUILDING.

Bethlehem Iron Company, Bethlehem. Building two 15-ton Siemens-Pernot furnaces.

Black Diamond Steel Works, Park, Brother & Co., Pittsburgh. Decline to give information.

Cambria Iron Company, Johnstown. Two 15-ton Siemens-Pernot furnaces. One 12-ton Basic-Pernot furnace.

Chester Rolling Mills, Chester. Two 15-ton Siemens furnaces.

Fort Pitt Foundry, Mackintosh, Hemphill & Co., Limited, Pittsburgh. Two 7-ton Siemens furnaces.

Frankford Steel Works, Adam Tindel, Frankford, Philadelphia. Building a 5-ton Siemens furnace.

Glenwood Steel Works, Leishman, Gordon & Snyder, Pittsburgh. One 5-ton Siemens furnace.

Grove, Grier & Co., Limited, Danville. Philadelphia office, 330 Walnut street. One 20-ton Siemens furnace.

Hussey, Howe & Co., Limited, Pittsburgh. One 7-ton Siemens furnace.

Juniata Iron and Steel Works, Shoenberger & Co., Pittsburgh. Two 12-ton Siemens furnaces.

Leechburg Sheet Iron and Tin Plate Works, Kirkpatrick & Co., Limited, Leechburg Office, 143 First avenue, Pittsburgh. One 10-ton Siemens furnace.

Linden Steel Company, Limited, Pittsburgh. One 7-ton and one 10-ton Siemens furnace.

Midvale Steel Company, Nicetown P. O., Philadelphia. One 7-ton and two 12-ton Siemens furnaces.

Pennsylvania Steel Company, Steelton. Office, 208 South Fourth street, Philadelphia. Two 30-ton Siemens furnaces.

Singer, Nimick & Co., Limited, Pittsburgh. One 10-ton Siemens furnace.

Soho Iron Mills, Moorhead & Co., Pittsburgh. One 12-ton Siemens furnace.

Spang Steel and Iron Company, Limited, Pittsburgh. One 7-ton Siemens furnace completed and one 10-ton Siemens furnace building.

Standard Steel Casting Company, Thurlow, Delaware County. One 10-ton Siemens furnace.

West Penn Steel Works, Joseph G. Beale, Leechburg. One 7-ton Siemens furnace.

KENTUCKY—1.

Mitchell, Tranter & Co., Second and Race streets, Cincinnati. Works at Covington, Ky. One 7-ton Siemens furnace.

TENNESSEE—1.

Roane Iron Company, Chattanooga. Two 10-ton Siemens furnaces.

OHIO—7 COMPLETED AND 1 BUILDING.

Burgess Steel and Iron Works, Portsmouth. One 8-ton Siemens furnace.

Canton Steel Works, Bolton Steel Company, Canton. One 10-ton Siemens furnace.

Cleveland Rolling Mill Company, Cleveland. Three 7-ton and two 15-ton Siemens furnaces.

Otis Iron and Steel Works, Otis Iron and Steel Company, Cleveland. Four 15-ton Siemens furnaces.

Portsmouth Iron and Steel Works, John Means, trustee, Ashland, Ky. Works at Portsmouth. One 10-ton Siemens furnace.

Solid Steel Company, Alliance, Stark County. One 10-ton open-hearth furnace.

Whitely, Fasler & Kelley, Springfield. Building an open-hearth furnace.

Youngstown Steel Company, Youngstown. One 20-ton Siemens furnace.

ILLINOIS—2.

Calumet Iron and Steel Company, Chicago. Four Siemens furnaces.

Springfield Iron Company, Springfield. Two 20-ton Siemens-Pernot furnaces.

CALIFORNIA—1.

Pacific Rolling Mill Company, 16 First street, P. O. Box 2,032, San Francisco. One Siemens furnace.

UNITED STATES.

Total number of open-hearth steel works in the United States: 35 completed and 3 building. Number of furnaces: 58 completed and 5 building. Annual capacity of completed works, 550,000 net tons ingots.

APPENDIX B.

IRON AND COMPOUND ARMOR PLATES.*

COMPOUND ARMOR PLATES.

Trials with iron and compound armor made in Spezia (1876) have proved that iron plates are out of date, and that a stronger armor must be adopted for protecting vessels against modern artillery. The Creuzot steel plates proved superior to the English iron plates, but did not afford sufficient protection, as they were shattered by projectiles, leaving the target entirely exposed. Cammell & Co. have, therefore, been experimenting in order to find out what changes in construction would insure the best qualities of armor. The result of their experiments was the compound armor, and the first vessel armored with the new plates was the Inflexible.

Since then the English armor-makers have adopted the methods for manufacturing compound armor described below:

THE PILE FOR THE COMPOUND ARMOR.

The pile is formed, first, by preparing the rolled iron plate to receive the steel; and, second, by casting and welding the steel layer to the same.

The welding of the steel consists only in taking advantage of the inclination of the liquid steel to unite with the white-hot iron plate, with which it is brought in close contact. The steel is simply poured on top of the iron plate at welding heat. How this is accomplished will be described below.

To receive the steel, the plate is mounted nearly vertical in a cast-iron flask. The steel is then poured from a trough above in several streams over the surface of the plate, washing off the oxides, which cover the plate. It happens that, when the liquid steel is very hot, these oxides partly melt, and, being lighter than the steel, under reasonably favorable circumstances, reach the surface. Another part of the oxides probably is reduced by the reaction of the hot steel to a lower degree of oxidation, forming carbonic oxide gas, which remains in the interior of the steel, causing blisters. The agitation of the liquid steel, when poured, promotes this reaction by mixing the oxide with the metal. The temperature of the liquid steel is so high that it

*A Technical Study, by J. Brink, lieutenant in the corps of mechanical engineers of the imperial Russian navy. Translated into German by L. K. Kuzmany, chief naval constructor in Pola. Partly translated from the German.

not only washes off the oxide from the surface of the plate, but also melts and carries away the iron from the places where it is flowing down. Fractures of the upper part of compound plates (as they stand in the flask), see Fig. 3, Plate I, show plainly the places where the steel was flowing down, washing out gutters, marked 1, 2, 3, up to 7, in the surface of the iron. In these gutters the steel most perfectly unites with the iron. Blow-holes cannot be found in these places, but are located on the ridges. This fact leads to the supposition that high temperature alone is insufficient to free the surface of the iron from scales; the liquid mass of metal must also assist in washing them away. As blisters form on places not altogether freed from oxide, it seems probable that the oxide combines with the carbon in the steel, forming new gases. Even the blistered parts are welded, but the blow-holes remain. They are small and distributed with a certain regularity. Their interior contains no slag, such as is found in other kinds of cavities, about which more later on. It therefore seems as if only a thin cover of oxide remained in these places. The gas causing blow-holes must form very slowly, as they neither rise to the surface nor flow together.

PREPARATION OF THE IRON PLATE FOR RECEIVING THE STEEL.

The iron plate is manufactured, as above described, long enough for two compound plates. After having been straightened under a press it is allowed to get cold and cut into two parts, each of which serves for one plate and has to be prepared for receiving the steel. The methods of Cammell and Brown are different as well technically as economically, and will therefore be described separately.

(*a*) *Cammell & Co.'s old method.*—On one side of the plate A, Fig. 4, Plate I, are bolted two steel channels extending the whole length of the plate. Holes R, 125 millimeters deep, 100 millimeters in diameter, are bored into both edges of the plate as near to the end B as possible. These holes are to facilitate the handling of the plate, and are, therefore, bored close to the end B, which is placed at the top of the mold. The plate is then placed on the movable bottom of a heating furnace; the channels B and the holes R in the edges are covered with brick and clay, and the bottom is placed in position in the heating furnace. When the plate has almost reached welding heat, the bottom is drawn from the furnace, the brick and clay cover is removed from the channels, the hooks GG are placed in the holes RR, and the plate is with a crane lifted in the mold C. The plate remains nearly vertical in the mold, and is so adjusted, with aid of the wedges DD and plates FF, that the channels fit closely to the inside of the mold. The open spaces are now filled with dry molding sand. The room inclosed by the upper surface of the plate, the inside of the box, the channels, and the brick-covered bottom of the box forms the casting flask. The steel unites intimately with the hot surface of the iron, while the welding to the steel channels is less perfect. Damp clay and sand are used to prevent the steel from leaking out through the joints. On the bottom of the mold is spread a layer of wet clay, and wet lumps of material are placed along all joints after the plate is in position. When, afterwards, molding sand is rammed in, these lumps are pressed into the joints and close to the edges. If some liquid steel should enter the joints, it immediately gets cold when coming in contact with the wet clay, and closes the joint. The steel is now poured,

and thus the bloom for a compound plate completed. Cammell & Co. followed the described method from 1879 till May, 1882, when the new method described below was introduced. The complete pile, which for a compound armor of 457 millimeters was 760 millimeters thick and weighed 38,000 kilograms, was transported from Grimesthorpe Works, where the Siemens furnaces are situated, to the rolling mills in Sheffield. Before rolling, the plate is put in a heating furnace for twenty-four to twenty-six hours. The reversing mill is worked by an engine of 600 horse-power. The rolls, 88 centimeters in diameter, make about fourteen revolutions a minute. After every passage of the bloom the rolls are brought together from 3 to 7 millimeters, according to the temperature of the metal. If one heat is not enough for reducing the pile to the required thickness, it is heated again for eight to ten hours. A condition for successful working is that the plate be uniformly heated throughout. All handling appliances at these works are worked by hydraulic power.

(*b*) *Cammell & Co.'s new method.*—The hot iron plate is taken direct from the rolls and placed on a brick base, A, supporting the mold B, Fig. 5, Plate I, which is similar to box C, Fig. 4, Plate I. The mold B is placed in a frame movable around the horizontal axis PP, and is only temporarily held horizontal, so that the plate may be conveniently pushed into it. The brick foundation is previously built to such a height that when the iron plate is placed on it the space between the top of the plate and the inside of the upper flask is equal to the thickness of the steel. The brick base is somewhat narrower than the iron plate. As soon as the plate is placed in the manner described on the brick bed, the cheeks NN are pressed towards its sides by means of screws. Their sharp edges cut into the iron, or, at any rate, press closely against it. The mold is now raised into nearly a vertical position, the spaces between the mold and the cast-iron cheeks NN and between these and the plate are rammed with sand and wet clay, and then the steel is poured.

The casting of the steel took place at the Grimesthorpe Works, in the steel foundry, which is situated about 2 miles from the rolling mills in Sheffield. On this account the first method proved impracticable. Another operation which made the casting very expensive was the mounting of the side bars, which required the cooling down of the iron plate after it left the rolls. Another heat was thus added. These circumstances caused the management to change their method. The new plan is now used for casting all plates. This plan is cheaper and better than the old one, but has also its drawbacks. The edges of the iron plate are always more or less covered with steel, which has to be removed from the edges before the rolling and while the plate is yet hot. This is hard and difficult work for the men, and cannot be accomplished without sudden shocks and a considerable reduction of temperature, especially on the surface of the steel and along the edges. Thus flaws and fissures are frequently formed, mostly along the edges of the steel. In the rolling they are so enlarged that they often reach within the limits to which the plate is afterwards cut. Small cracks scattered all over the plate are hardly injurious, but are, nevertheless, not at all desirable and ought not to be found on perfect plates. When the new method is followed, the edges of the iron will get covered with steel, because the rough plate is placed in the mold just as it leaves the rolls, without first being trimmed or straightened.

The long sides are also too rough to offer the cast-iron cheeks NN a sufficiently good bearing for making a tight joint. When the old plan is adopted, the lower end of the iron plate is planed before the plate is placed in the mold; it then rests close on the brick foundation. With the new method this is not the case.

(*c*) *J. M. Brown & Co.'s method.*—To prepare the iron plate for receiving the steel, the bars AAB are bolted to the half, A, of the plate. The section of these bars is shown by Fig. 6, Plate I. The side bars AA are of steel, the end bar of iron. On top of these bars is bolted a rolled-steel cover 50 to 60 millimeters thick; that is, about one-half to one-third of the thickness of the whole steel layer in the armor pile. Between the end bar and the cover an opening through which the cinder is discharged. Thus the cover is resting only on the side bars. To keep the steel cover is left, at the desired distance from the iron plate, while in the heating furnace, twenty-five regularly distributed steel props are placed between the two so that their larger ends support the steel cover, while the smaller ones rest in holes bored into the iron plate. When the side bars, props, and steel cover are in place, the whole is carefully covered with clay to prevent the edges from being burnt. The opening through which the steel is to be cast is also covered with fire-brick and rammed with clay. Then the plate is placed in an ordinary furnace to be heated before casting the steel. The appliances for casting the steel are placed in the same building as the rolling-mill, and nearly on the floor level. When nearly reaching welding heat the plate is taken out of the furnace, stripped of the brick and clay covering, and, with the aid of tongs of special design, placed in an almost vertical position and moved to the casting place. Here it is lowered between two cast-iron plates, C and D, so that the steel cover fits closely to the upper plate D, which is fixed. The planed end of the iron plate is turned downward. The cast-iron plate C is pressed against the wrought-iron plate by means of screws. As at Cammell's, all joints are closed with clay, the opening spaces rammed with sand, and then the plate is ready to receive the steel. The steel is poured into the space E, and must consequently weld to both the upper side of the iron plate and the bottom of the steel cover. It is supposed that the steel props, which on purpose are made of hard crucible steel, being brought nearly to the melting point when in the heating furnace, afterwards completely fuse with the steel around them. When this plan of casting is followed the steel cannot leak out and cover the edges of the plate. The arrangements are, therefore, very practical and leave very little to wish for.

Brown uses, instead of the ordinary molding sand, a yellow sand, which leaves the upper surface of the armor smooth, while the ordinary black molding sand, when the plate is being heated, eats into the metal, leaving a rough surface. As a rule smoother work is accomplished in this manner. Later on, when comparing different armor-plate piles, we will further discuss the practicability of the Brown method.

THE CASTING OF THE STEEL.

It is not material whether Bessemer or Siemens steel is used, experiments having shown that the quality of the armor is not influenced by the process by which the steel is produced. Up to May, 1882, Cammell exclusively used Siemens steel, because

the casting was done at Grimesthorpe works, where there is no Bessemer plant, but from the beginning of September, 1882, Bessemer steel was adopted, as there are only Bessemer converters and no Siemens furnaces at the place where the new and improved process is carried out. During the interval, May to September, 1882, when the old method was not entirely abandoned, both kinds of steel were used. In Brown's works only Bessemer steel has been used, for the reason that it is hotter and better adapted than the Siemens steel for the process carried out at these works. Liquid steel is run from the converter or open-hearth furnace into a ladle, which is brought to the casting place. The steel is here poured into a trough or spout placed over the mold, and flows down on the iron plate through holes in the bottom of the trough.

THE THICKNESS OF THE STEEL LAYER.

The experiments of Cammell & Co., 1878 and 1879, at Portsmouth and Shoeburyness, with compound armor of different construction, and also the firing tests of the armor of the Inflexible, which was the first vessel armored with compound plates, have shown that it was most advantageous to make the thickness of the steel equal to one-third of the entire thickness of the plate. Thus the height of the channels H (Fig. 4, Plate I), which are used by Cammell for confining the steel, must be proportioned accordingly. The rough steel casting must be 1½ times to 3 times as thick as the steel layer of the finished compound plate. For heavy plates the proportion is 1½; for thin ones, 3. These conditions and the required size of the finished armor determine the dimensions of the iron plate to which the steel is to be welded. At Brown & Co.'s works the same rule is followed for determining the thickness of the steel casting in proportion to that of the finished plate. On account of the steel cover, however, the casting is only one-half to two-thirds of the thickness of the entire steel part. The steel cover is rolled from a 225 millimeters thick bloom of steel, similar to that which is used for the casting.

THE CHEMICAL COMPOSITION OF DIFFERENT KINDS OF STEEL USED FOR COMPOUND ARMOR.

The steel used for compound plates contains from 0.5 to 0.9 per cent. of carbon. It is considered that the plate is the better the harder the steel is, but on the other hand are the difficulties in rolling and bending the plate increasing with the hardness. The hardness of the steel ought probably to vary with its thickness. Thus for very heavy plates the thickness of the steel ought to be less than one-third of the thickness of the plate, but the metal ought to be so much the harder. Tests made in Prussia indicate that a compound plate with steel containing 0.4 per cent. of carbon does not possess any advantage over a good iron armor. When the percentage of carbon rose to 0.5 per cent., the plate proved from 12 to 15 per cent. better than the iron plate, and with 0.6 carbon splendid results were obtained. On comparing different compound armor of English make with Creuzot steel plates, for which steel with 0.43 per cent. carbon is always used, it was found that the penetration of the projectile was less for the compound plates only when the percentage of carbon was at least 0.70. As

other elements also influence the quality of the steel, chemical analyses and results of tensile tests for different compound armor plates are given.

A.—*Chemical composition.*

No. of analyses.	Kind of armor.	Elements.					
		C.	Si.	Mn.	P.	S.	Cu.
1	Average results of analyzed samples from Cammell compound plates made 1882, tested in Prussia with excellent results.	0.573	0.173	0.617	0.054	0.046	0.026
2	305-millimeter plate tested in St. Petersburg in October, 1882	0.97 %	.....	.....	.....	.....	.....
3	252-millimeter plate tried in Portsmouth in February, 1882	0.842	0.380	2.060	0.093	0.060	0.00
4	252-millimeter test plate made for the Prussian Government	0.75 %	0.181	1.450	0.068	0.052	0.00
5	150-millimeter plate No. 711 of the armor for the frigate Dmitri Donskoi, tested in Portsmouth in March, 1883.	0.66	0.10	0.93	0.03	0.05	0.02
6	Another 150-millimeter plate of the armor for the frigate Dmitri Donskoi, accepted under No. 521.	0.62	0.12	0.90	0.201	0.301	0.02

B.—*Physical tests of compound armor plates.*

(1) Test pieces taken from plate No. 711 (chemical analysis No. 5) with the grain: ultimate strength 66 kilograms per square millimeter; elongation 1.17 per cent.

Across the grain: ultimate strength 62.4 kilograms per square millimeter; elongation 0.39 per cent.

(2) Test pieces taken from plate No. 521 (chemical analysis No. 6) with the grain: ultimate strength 67.8 kilograms per square millimeter, elongation 1.9.

Across the grain: ultimate strength 96.2 kilograms per square millimeter; elongation 1.8.

(3) Average result of physical tests of pieces taken from plates of different thickness.

The ultimate strength varies from 61.2 kilograms and 76.9 kilograms per square millimeter of area. The elongation is slight, varying from 0.20 to 2 per cent. for a 203 millimeter long test piece.

In the latter part of 1880, or in the beginning of 1881, Cammell & Co. started manufacturing compound armor on a large scale, making the bloom according to the first method, and casting the steel in vertical position. The use of side bars is not peculiar to the method. At the time named the testing of a large number of armor plates for the Inflexible was completed. The greater part of the 229-millimeter compound plates for this vessel have steel slabs 102 millimeters and 127 millimeters of iron backing. Only the last plates made are compound of only 76 millimeters steel and 153 millimeters iron. Later all compound armor has been so constructed that the steel measures one-third of the whole thickness of the plate. Recently John Brown & Co. manufactured compound plates to be experimented on with artillery at Shoeburyness, in which the steel only measured one-fourth of the entire thickness. When the heavy armor for the Ajax was being bent, fissures penetrating the steel were opened. Cammell & Co. therefore adopted the Brown method in using a steel cover on top of the bloom. Their plan was, however, not so practical as Brown's, inasmuch as the plate was held horizontal or slightly inclined when the steel was cast. The method was soon abandoned, when the plates tested by firing proved that the welding of the steel to the iron was imperfect, and it had been found also that compound plates made without the covering plate could stand a great deal of bending. The result was attained partly by changing the arrangement of the layers in the iron plate, partly by

bending the plates under more favorable circumstances. Through rivalry between the manufacturers, the results of many experiments, made by the works for their own information, almost invariably remain their private possession and are kept secret. Therefore the details of these cannot be published in print. Thus it may happen that one firm is spending money for the same experiments which have already consumed the work and capital of other manufacturers. These unfavorable circumstances prevent me from giving in detail the results of Cammell & Co.'s experiments. Brown & Co. did not take part in them. The experiments were carried out in a thorough manner, and had for their purpose the best solution of the armor question, viz: Whether it would be preferable to endeavor to improve the method of making compound armor or to make armor out of steel only.

A superficial enumeration of the different kinds of plates tested by Cammell & Co. may be of interest, indicating the tendency of the experiments, which led to the adoption of armor plates with a steel layer of one-third of the whole plate.

(1) *Series of 229 millimeter armor plates tested at Portsmouth and Shoeburyness, July, 1877, to February, 1878.*

No. of plate.	Testing place.	Construction of plate.
1	Portsmouth	Rolled iron plate.
2	Shoeburyness.....	Steel plate, Cammell subcarbonized, tempered in water.
3	Shoeburyness.....	Same; not tempered.
4	Portsmouth.....	Like No. 3, } Steel, with 0. 14. carbon.
5	Shoeburyness.....	Like No. 3, }
6	Portsmouth	Steel layer 127 millimeters thick, with 51 millimeters of iron on both sides.
7	Shoeburyness.....	Rolled steel plate with iron backing.
8	Shoeburyness.....	Like No. 7, hammered.
9	Shoeburyness.....	Like No. 7.
10	Portsmouth.....	Like No. 7.
11	Portsmouth.....	Hard steel (C=0.8%) rolled between slabs of softer steel. The hard steel was 127 millimeters thick.
12	Shoeburyness.....	Like No. 11.

(2) *Series of 229 millimeters thick plates tested March to December, 1877.*

12	Portsmouth.....	Steel subcarbonized C=0.17% not tempered, rolled.
13	Shoeburyness.....	Like No. 12, tempered in water.
14	Shoeburyness	Like No. 12, tempered in oil.
15	Portsmouth.....	Like No. 12, but of steel, with C=0.2%.
16	Shoeburyness.....	Like No. 15, but tempered in water.
17	Shoeburyness.....	Like No. 15, but tempered in oil.
18	Portsmouth.....	Compound with 127 millimeters hard steel and 102 millimeters iron.
19	Shoeburyness	Like No. 18.
20	Portsmouth.....	Compound with 127 millimeters soft steel and 102 millimeters iron.
21	Shoeburyness.....	Like No. 20.
22	Portsmouth.....	Compound with 76 millimeters hard steel and 156 millimeters iron.
23	Shoeburyness.....	Like No. 22, but planed down about 3 millimeters on the front side.
24	Shoeburyness.....	Like No. 22.
25	Portsmouth.....	Compound with 153 millimeters soft steel and 76 millimeters iron.
26	Shoeburyness.....	Like No. 25.
27	Shoeburyness.....	Like No. 25, but hammered.
28	Portsmouth	Iron plate of special construction, with 140 millimeters soft iron in the middle
29	Shoeburyness....	Like No. 28.
30	Portsmouth.....	Steel plate made of welded steel bars.
31	Shoeburyness.....	Like No. 30.
32	Portsmouth	Iron plate of special construction 89 millimeters hard and 140 millimeters soft iron.
33	Shoeburyness	Armor composed of one steel and one iron plate separated by a brass layer.

In addition one cemented iron plate and one steel plate out of which the carbon was extracted were tested.

COMMENTS ON THE DESCRIBED METHODS FOR MAKING BLOOMS FOR COMPOUND ARMOR.

Brown's practice is more expensive than the first method used by Cammell & Co., and cannot at all compare with their later one, which is the most economical of all. The welding is often a failure, even in Cammell's practice, where the steel is to unite only with one side of the hot, thick, and slowly-cooling iron plate. Such a failure, probably, is a still more frequent occurrence at Brown's, where the steel has to weld on twice as large a surface. It is more difficult to obtain a good weld with the steel cover, which is thin, and liable to cool down rapidly. Taking further into consideration that the oxides formed during the reheating no doubt prevent the welding, and that it is impossible to pour the steel at the same time over the surface of the iron plate and the steel cover, there are technical reasons enough to assume that this method must be impractical, at least so long as no means have been found to free the surface from oxides. Up to date no practical invention in this direction has been made. The author made an experiment in Cammell's works to wash the surface of the iron with liquid steel before casting. The steel partly dissolved the scale, partly washed it off. For several reasons, however, this operation was deemed impractical, and the experiments were abandoned.

When the difficulty of welding the steel in these blooms is not considered, it would seem as if the Cammell plates were inferior to Brown's, in which one-half to one-third of the steel layer consists of material more thoroughly worked than the steel simply poured in. Trials with plates from both makers, however, show that Brown's plates never are better than Cammell's, and in several cases even prove inferior. The advantage that the steel cover might give Brown's plates is thus counterbalanced by the frequent drawbacks of imperfect welding, which is due to the presence of just this cover. The cylindrical steel props also exercise an injurious influence. If the existence of interior strains in plates made of two different materials is admitted, it is evident that these strains must be greater in Brown's than in Cammell's plates. The only advantage afforded by the steel cover is that it prevents the formation of outside cracks when the plates are bent. This is, however, no great advantage, because if the plate is made of steel of sufficient hardness, high in carbon, and proportionally low in manganese and silicon, the cracks can be avoided without any cover. Besides, all of Cammell's plates do not show fissures, while many of Brown's crack in spite of the covering plate.

As both of the described casting methods have their known disadvantages, a third plan will be mentioned, which is a combination of Cammell and Brown's, and which seems more practical than either of these. According to this the iron plate is moved direct from the rolls to the casting place by means of a crane and a kind of tongs. It is then lowered into the mold in vertical position between two plates in the same way as at Brown's Fig. 6, Plate I. At first, however, it is kept suspended between the two plates, leaning against two square bars, which are somewhat higher than the cheeks, and placed between these, resting against plate D. The square bars are not shown on the drawing. The plate is then, by means of a hydraulic press attached to the plate C, pushed tight against the square bars. This operation serves only to straighten the iron plate, if required. The water is now turned off. The plate C is brought back to

its original position, leaving behind it an empty space, which later on is to be filled with steel. Enough clay and sand are thrown into this space to close the joint between the plate and brick base. The iron plate is slightly moved from plate D, the square bars which were used for straightening the plate are then removed, and the wrought-iron plate is lowered into the brick foundation. On the plate D are now placed two wedges, against which the wrought-iron plate is pushed with the hydraulic press. After the sides have been rammed with clay and sand the preparation for the casting is completed.

When this method is adopted, Cammell's expensive apparatus can be dispensed with. The steel cannot get on the back side of the iron. Only one side bar is consumed for each operation. This can be placed anywhere on plate D, depending on the required width of the armor. The other side bar is, before the casting, rigidly fastened to the side of plate D, where it forms a kind of guide. The height H of the side bars depends on the amount of metal required to make the steel layer of the finished plate sufficiently thick. The plate is only rolled lengthwise. Always using these side bars of uniform height, blooms for plates of various thickness can be cast. If, for instance, H 156 millimeters plates, 115 millimeters to 305 millimeters thick, with 32 millimeters to 102 millimeters steel slab can be made only by more or less work in the rolls.

ROLLING COMPOUND ARMOR PLATES.

About one half hour after the steel is cast, by one method or another, the plate is lifted from the apparatus and placed in a heating furnace. The heating must be so controlled that the steel does not get too hot, while the iron is well heated. The plate is therefore placed in the furnace with the steel downward. When hot it is rolled in the mill used for rolling the iron plates; the only difference is that the rolls are let down less after every passage. The plate must not be too much heated. When, therefore, the work in each passage is gradually getting less, it is necessary to reheat the plate once or sometimes even twice. Thin plates are rolled until cherry-red. The color, however, is of little importance. Direct from the rolls the plate is taken to the press to be straightened and bent to template. It is submitted to no other metallurgical process; but when the shape is complicated, the heat from the rolling does not suffice for the bending. Such plates are therefore once more heated to bright red, either, as by Brown, in a furnace with loose roof, or, as by Cammell, on an open hearth. The latter way of heating is imperfect and must be frequently repeated. After the plate is rolled, straightened, and eventually bent, no more metallurgical processes remain, but the plate goes to the machine-shop of the works to be cut to the required dimensions. The description of the manufacture of compound armor is therefore now ended. It remains only for the sake of completeness to describe some methods observed at the English armor works for making plates of special shape.

PLATES FOR SPECIAL SECTIONS.

Besides plates of rectangular section, shapes like those shown by Figs. 7 and 8, Plate I, have of late years been used for vessels. The metallurgical preparation of the material for these is the same as for the ordinary plates, the only difference being

in the shape of the piles. The section of the pile depends on the section of the finished plate. They must be similar to each other. For the plate B, Fig. 8, Plate I, the pile is arranged as shown by Fig. 9, Plate I. Three rows of puddled bars of same thickness are placed in one or two layers between cover plates. Thus the pile is given the same thickness from L to R throughout its length. The ratio between the thickness at PR and the thickness at NM is the same as that of corresponding places on the armor plate. The layers between PR and MN must be arranged so as to give a gradual change of thickness. Naturally the pile for a plate having a section like A, Fig. 7, Plate I, must be arranged throughout like the part PRMN in Fig. 9, Plate I. The puddled bars for the interior layers of this kind of piles are made from scrap or iron worked two or three times over. They are always of the same thickness, or nearly so. As a rule the metal for these interior layers is not especially made, but taken from stock of suitable grades. The bars are either 25 millimeters, 18 millimeters, or 12 millimeters thick; and the taper of the pile is attained by laying the bars two or three on top of each other at the thick part, but only single at the thin end. A perfectly gradual reduction of thickness can therefore not be obtained in this manner. To counteract the injurious influence which such a way of piling might have on the quality of the armor, the difference between the thickness of the various parts is not made as large as in the finished plate. As an explanation, the dimensions are given of three piles which have been used for the plate section A, Fig. 7, Plate I. The height of these plates was reduced, the first from 520 millimeters to 390 millimeters, the second from 620 millimeters to 545 millimeters, and the third from 635 millimeters to 557 millimeters. Piles so arranged were used for wrought-iron plates of the special section in question.

When a pile is to be composed for a compound plate of same section, the previously described iron pile is welded and partly rolled. Though the pile was originally built with regard to the final section of the plate, it is always in the first rolling given a gradually tapering section (see A, Fig. 7, Plate I). The plate thus obtained is cut into halves crossways and side bars are bolted to it, as on the ordinary plates. These side bars are of different height, the one at the thicker side being higher than the one at the small side. The difference in the height of the bars is proportional to the difference in thickness of the sides of the plate. Their absolute height is so calculated that the steel layer will be one-third of the thickness of the plate, allowance being made according to experience for the rolling. The old Cammell casting process required the piles to be composed as described. With the simplified new process it is enough to build a sloping brick base, on which is bedded the wrought-iron plate, made from a pile similar to the one shown by Fig. 9, Plate I.

ROLLING ARMOR OF SPECIAL SECTIONS.

The special shapes are rolled in the same train as the ordinary plates, but for plates of the section shown by Fig. 7, Plate I, the upper roll is given an inclined position. The bottom roll remains horizontal. The inclination of the top roll is in proportion to the difference between the sides of the plate, and is obtained by placing beveled washers

under the bearings. When a half-parallel, half-wedged shape section (Fig. 8, Plate I) is to be rolled, keys are placed only on the upper bearings for the top roll, and the position of the roll after every two or three passes is changed from horizontal to inclined, and *vice versa*. This method must be followed if longitudinal cracks through the steel are to be avoided. Such cracking generally occurs, because the work of the rolls cannot at the same time be distributed on the whole cross-section of the armor. It cannot altogether be avoided. Smaller or larger fissures do either open in the rolling or they appear when the plate is afterwards being bent.

The compound armor pile is heated and rolled with the steel down. When rolled, as above described, into a section like Fig. 8, Plate I, it is therefore necessary to bend the one-half of the plate under press before the required section is finally obtained. The drawings show this plainly: Fig. 10, Plate I, is the compound pile; Fig. 11, Plate I, is the plate when leaving the rolls; Fig. 12, Plate I, is the finished plate. The part A B must therefore be bent under press from its original position, indicated by the dotted lines (Fig. 13, Plate I), to the position shown by the drawn lines, same figure. From what has been said an idea can be formed of the difficulties in rolling similar sections, and how impractical the method is. It was in 1882 and 1883 that such plates were first used for vessels. The first ones were made by Cammell for the Russian frigate Wladimir. Frequent mishaps soon caused the method to be abandoned, so that the last plates delivered for the Wladimir were rolled from piles with parallel surfaces, composed as shown by Fig. 11, Plate I. The iron part of this pile was wedge-shaped, and the steel casting such that the section of the pile had the same thickness all over. The pile was rolled down to a plate of even thickness (Fig. 15, Plate I), a wedge-shaped part of the iron (Fig. 15, Plate I, A B C) was planed off, and the plate reheated and bent to the desired section. J. Brown & Co., in making similar plates for the Russian iron-clad Dmitri Donskoi, availed themselves of the latter method, only introducing the steel covering-plate.

The foregoing description of the manufacture of compound armor gives an idea of the faults and deficiencies belonging to the system. They are of two kinds: those to which all plates are liable, and those which are accidental only. Amongst the former may be mentioned blow-holes in the steel, which the English Admiralty consider unavoidable. In what degree they are injurious to the quality of the armor cannot be ascertained. To do so it would be necessary to test by fire a number of blistered and sound plates and compare the results; then blow-holes are not distributed all over the plates, but are mostly scattered along the edges. The blow-holes are more developed the thicker the steel is. This fact justifies the conclusion that the longer time in cooling prevents the gases from escaping through the steel and aids in the formation of blisters. The gases are formed partly during the process of steel making, partly through the reduction of the oxide covering the iron, and partly through the pouring of the steel in thin streams. The oxides unite with the carbon in the steel when sufficiently hot. If this explanation is not satisfactory, it will prove difficult to account for the numerous blow-holes in plates, in which the steel contains about 0.9 per cent. of carbon.

The blisters gradually forming have a tendency to rise upward, where the metal is warmer and more liquid. On their way the small blisters unite into larger, which

have a still stronger tendency to rise as long as the steel is liquid. Upward means here toward the edge of the plate, as this, during the casting, is kept in a nearly vertical position. Fractures of heavy plates show fewer blow-holes in the center than toward the edges. If, therefore, armor plates were more closely trimmed than now is the case, the blistered parts would be removed, so that the edges would be as solid as the middle. This would naturally increase the cost of the manufacture by making more scrap, and is not absolutely necessary; nevertheless, it would be desirable to have some means for making the steel perfectly homogeneous without injuring its physical properties. The blow-holes are quite different from the small blisters described in the chapter treating the welding of the steel. The latter are very small, and appear always on the surface of the iron plate between the channels cut by the liquid steel. These cavities are perfectly free from scales. The blow-holes, on the other hand, are irregularly scattered in the whole steel layer. They are of irregular shape, forming cavities 100 to 125 millimeters wide and deep. Fig. 16, Plate I, gives a true copy of the edge of a blistered plate. They often form either open holes or clusters of spongy metal mixed with slag. It seems, therefore, probable that the slag is decomposed by the reaction of the steel. Another general fault of all armor plates is the presence of abnormal interior strains, which on the least provocation make their appearance as cracks. They are the result of having to work under same circumstances hard steel and soft wrought iron firmly united with each other. If, however, the welding of the steel to the iron is perfect, and the iron backing is sufficiently thick, there is no reason to fear that this fault will unfavorably affect the resistance of the plate.

Amongst the occasional faults we find: imperfect welding between the iron and the steel, cracks, the burning of some parts of the steel, and defects in the iron plate, such as exfoliation and bad welds.

Bad welding between the iron and steel is a grave defect in compound armor. The following will prove the statement:

Compound plates have a tendency to crack through the steel layer. When projectiles strike them, two different kinds of fissures are generally formed, viz, radial and concentric. The concentric cracks are generally more numerous after the first shots. These cracks may evidently cross each other, in which case that part of the plate in which the weld is imperfect is ruined by the dropping off of the steel layer. Cracks through the steel layer appearing before the firing are either longitudinal, which form during the bending or even during the rolling, or cross cracks, which appear after the steel is cast. Cross cracks may also open when turret-plates, which have sharp curves, are being bent Firing tests have proven that such cracks do not injure the plate, provided the welding is perfect and the steel is hard enough. The burning of the steel happens occasionally, but hardly deserves consideration, as the burnt places, generally extending along the edges, are trimmed off when the plate is cut. It does occur, however, that the burnt place extends a few centimeters into the front part of the plate.

DEFECTS IN THE IRON PART OF THE COMPOUND PLATE.

Exfoliation is not considered dangerous, and the bad place is simply chipped out. When a bad weld is of great extent compared with the thickness of the iron layer,

or covers a large surface, the plate is rejected because it is known that the parting of the metal facilitates the penetration of the shot. The English Admiralty came to this decision when testing iron armor, and the decision has been justified later on by the experience with compound plates. When these larger defects in the welding exist, the shock and jar cause the steel and the top slab of the iron to part from the iron body. This is a more frequent occurrence with very thick plates when struck by heavy projectiles than with lighter plates. The reason is that the large projectiles strike with a comparatively greater energy and jar the plate much more than the lighter shots.

INSPECTION OF THE MANUFACTURE OF ARMOR PLATES.

In describing the defects pertaining to compound armor plates, it has been shown that the imperfect welding between the iron and steel and the lack of solidity of the iron parts are the greatest faults of this kind of armor. From facts established by a large number of comparative experiments with compound plates, it is concluded the conditions for good plates are: That the steel ought to be sufficiently hard, carbon 0.6 to 0.9 per cent.; the thickness of the steel layer equal one-third of the whole thickness of the plate. The English Admiralty employs for the inspection of the manufacture of armor several specialists in this branch of the iron industry, under direction of an old expert. To these specialists belongs also the inspection in the iron and steel works of the different kinds of material manufactured for the Admiralty.

They control and supervise the manufacture of the armor plates until finished, according to the rules given in this paper. They have in certain cases, and with the approval of their chief, the right entirely to stop the manufacture. The chief inspector designates, according to his own judgment, the plates which are to be tried by firing tests. The acceptance of plates which are defective depends on him. If he does not want to decide on his own responsibility, he can arrange to have a special commission sent out for this purpose.

In ordering the 48-centimeter armor for the iron-clad frigate Italia, the Italian Government has specified that makers are to send one sample plate to Spezia for trial. If this plate proved satisfactory, it was stipulated in the contract all the plates in the order must contain the same percentage of carbon as the steel in the trial plate. Then three test-pieces were taken from every plate, and each test-piece was divided into two halves, one of which was analyzed in the chemical laboratory of the works, while the other half, with a certificate of identity from the inspector, was forwarded to Italy in case of a checking analysis being required. The difference in the results of the analyses must be very slight.

THE TESTING OF COMPOUND ARMOR PLATES BY ARTILLERY FIRE.

It seems as if the English Admiralty up to this time (1883) has established no fixed rules for testing compound armor plates of different thickness, probably because as yet no sufficient number of tests with iron and compound plates have been made to warrant the establishment of reliable rules for the purpose. Armor plates for the Colossus were made from 356 millimeters to 406 millimeters thick, and for the Collingwood from 406 millimeters to 457 millimeters. To try the quality of these orders a test-plate 279 millimeters thick was each time rolled and fired at; first with a 230-

millimeter, then with a 254-millimeter gun. When armor was ordered lately for the Imperieuse, a 254-millimeter test plate was exposed to fire from a 259-millimeter gun.

Below follow—

(1) The results of trials with a series of couples of 356-millimeter iron plates and 305-millimeter compound plates. Each corresponding pair tried with similar shots and same charge of powder.

(2) Specifications for compound armor plates at different times made for the English Admiralty.

(3) Extract from the contracts of the Italian navy department concerning the approval of 48 centimeters thick armor.

(4) Results of the trial of other compound armor and some steel plates.

(1) *Results of experiments with a series of couples of 356-millimeter iron plates and 305-millimeter compound plates.*

Type of—		Energy in tons per 1 centimeter of circumference of projectile.	Penetration of projectile into the plate.	Remarks.
Plate.	Projectile.			
			Millimeters.	
356 millimeters, iron	Steel	62.	264	
305 millimeters, compound		63.2	147	
356 millimeters, iron	Palliser chilled iron	62.8	377	
305 millimeters, compound		63.	106	
356 millimeters, iron	Steel	63.5	.....	The plate was penetrated.
305 millimeters, compound		63.1	212	The plate remained whole.
356 millimeters, iron	Steel	63.7	302	On the back of the plate appeared a fissure 70 millimeters wide.
305 millimeters, compound		63.1	Insignificant.	The projectile was crushed.

While these experiments had for their proper object only the testing of the quality of projectiles, they are, however, of interest for comparing iron plates of 356 millimeters with compound plates of 305 millimeters. The fire was delivered with similar shots and same charge of powder.

(2) SPECIFICATIONS FOR TESTING COMPOUND ARMOR PLATES, FROM TIME TO TIME, GIVEN BY THE ENGLISH ADMIRALTY.

(*a*) *Armor for the Inflexible.*—From every plate of the armor of the turret one piece was cut and tested. The piece was cut from the plate after it was bent. As a rule, it measured 2.44 meters by 1.83 meters. In cases where the dimensions of the plates did not allow the cutting off of such a large piece, a smaller one was considered sufficient. The piece, if approved, must stand 5 shots from a 230-millimeter gun with chilled shot and a charge of 22.7 kilograms of powder. The striking points were 0.61 meters apart. At this test no penetrating crack must open, nor must the shot go through the plate.

(*b*) *Plates for the Ajax and the Agamemnon.*—The plates to be tested were designated by the inspectors. The firing took place at Shoeburyness, with a 230-millimeter gun (weight of gun being 38 tons). The shot, of forged steel, weighed 371 kilograms. The velocity of the projectile was 441 meters. The test-plate, 356 millimeters thick, was required to stand 3 shots without showing penetrating cracks or being shot through.

(*c*) *Plates for the Colossus.*—As the Admiralty was unable to submit 365-millimeter and 406-millimeter compound plates to proportionally severe tests, the test-plates were rolled down to 229 millimeters, then tried with a 23-centimeter gun.

(*d*) *Plates for the Collingwood.*—The test-plates of 406 millimeters and 457 millimeters' thickness were rolled down to 229 millimeters and tried with a 230-millimeter gun. After it was found that the plates without difficulty stood the test, they were further fired at with a 254-millimeter gun, 181 kilograms shot, and powder charge of 34 kilograms' weight each 3 shots. Having been convinced of the great resisting power of compound plates, the authorities decided for the future to submit armor plates, hitherto tested with 230-millimeter gun, to the fire of a 254-millimeter.

(*e*) *The armor of the Imperieuse.*—The plates are made 254 millimeters thick, and tested by means of a 254-millimeter gun, chilled shots of 181 kilograms' weight, and a charge of powder of 32 kilograms.

(*f*) *Testing of armor plates for the frigates Wladimir, Monomach, and Dmitri Donskoi.*—The testing of the armor plates for these vessels was also performed at Portsmouth. The 152-millimeter thick plates were fired at from a distance of 915 meters with a 180-millimeter, 6½ tons, muzzle-loading gun, charged with Palliser chilled projectiles of 65 kilograms' weight and 6.35 kilograms powder. Three shots were fired. The 140 millimeter plates were tried in the same manner. The charge of powder, however, was only 5.44 kilograms.

(3) THE SPECIFICATION OF THE ITALIAN NAVY DEPARTMENT FOR TESTING 48-CENTIMETER THICK COMPOUND ARMOR PLATES.

The plate to be tested at Spezia was rectangular and fixed on a wooden target. In the center was drawn an equilateral triangle, at the points of which the shots were to strike. The side of the triangle was not less than 1 meter, and none of its points were closer to the edge of the plate than 0.8 meter. The fire was delivered from a 45-centimeter muzzle-loading gun with chilled shots of the type adopted in the Italian navy. The weight of the shot and the charge of powder were so calculated that the energy would be sufficient to break through a 25 per cent. thicker wrought-iron armor with wood underlayer. The first shot striking must not make any penetrating crack, and none of the three projectiles must pierce the plate. The energy of the shot is calculated by the Italian navy formula: D 0.03498, S 1.868, where D equals the energy of the projectile in meter tons on 1 centimeter of its circumference, and S equals thickness of armor in centimeters.*

* The experience gained by the similar firing experiments with 48-centimeter thick steel armor at Creuzot, and with the equally thick compound plates of Cammell and Brown, at Muggiano, in November, 1882, have caused the Italian navy department to test the compound armor for the Italia according to the following specification:

(1) The plate chosen for test is fixed on a target of wood 80 centimeters thick in the manner which the manufacturer himself may designate.

(2) Only one shot is fired at the plate, which must be struck in the center. For the firing is used a 45-centimeter gun, and a Gregorini chilled projectile, which latter, when striking, must develop sufficient energy to penetrate about a 25 per cent. thicker iron plate. The energy to be given to the shots for this purpose is to be calculated according to the familiar Spezia formula.

(3) If also after this shot a few cracks are visible, not a single piece must break loose or fall to the ground. To insure that all the plates in the order will answer as well as the one which has passed the firing test, pieces are taken from them all, including the one which is to be fired at, and tested physically according to stipulations made from testing the armor for the Dandolo. The last firing test carried out at Spezia in September, 1883, with compound armor from Cammell & Co., and from Brown & Co., intended for the Italia, were in fact already performed according to this specification. We will report on these tests later on.—K.

(4) RESULTS OF THE ARTILLERY TESTS ON SOME COMPOUND AND SOME STEEL ARMOR PLATES, DRAWINGS OF WHICH PLATES, AFTER THE TEST, ARE ATTACHED.

(*a*) 152-millimeter compound armor plate, Cammell's works, was selected from the first lot of plates for the frigate Wladimir; (*b*) selected from the second lot; (*c*) 152-millimeter compound plates from Brown & Co.'s works, selected from the first lot of plates for the frigate Dmitri Donskoi; (*d*) 203-millimeter compound armor, from Cammell & Co.'s, for the Imperieuse; (*f*) 239-millimeter compound plates for the Collingwood; (*g*) 305-millimeter armor plates, from Cammell's works, tested in St. Petersburg; (*h*) 48-centimeter compound plates from the works of Cammell & Co. and Brown & Co.; also, one steel plate of same thickness from Creuzot, tried in Spezia; (*i*) three steel plates of best quality, submitted to firing tests in Havre, for the inspection of the armor delivered for the French iron-clad Terrible.

THE ONE HUNDRED AND FIFTY-TWO COMPOUND ARMOR PLATES A, B, C, FIG. XVII.

Plate A had already, before the test, a few cracks going through the steel layer. On the drawing they are marked A. In the steel part of plate B no defects were discovered. Both plates served for testing the armor of the frigate Wladimir, manufactured by Cammell & Co. The plate C had no defects whatever, and served as test-plate for the armor of the frigate Dmitri Donskoi, delivered by Brown & Co. All three plates were tried at Portsmouth under absolutely the same conditions: 18-centimeter gun, muzzle-loader, 7½ tons weight; distance of the plate from the muzzle of the gun, 9.40 meters; charge of powder, 6.3 kilograms; chilled projectile from Palliser, 52 kilograms weight; distance of striking point, 610 millimeters.

Results of tests.

A.—FRONT SIDE OF PLATE.

Number of shots.	Maker of armor plate.	Penetration of projectile.	Cracks and openings caused by the shots.
		Millimeters.	
1	(*a*) Cammell	61	Six new superficial cracks, besides those already there before the test.
	(*b*) Cammell	61	Nine superficial cracks.
	(*c*) Brown	112	Four superficial cracks.
2	(*a*) Cammell	90	Three new cracks were opened, and those already there were widened.
	(*b*) Cammell	79	Eleven new cracks, superficial.
	(*c*) Brown	Did not stand.	Three new insignificant cracks were made.
3	(*a*) Cammell	....do	Two new cracks were formed, and those there before were lengthened.
	(*b*) Cammell	....do	Three insignificant cracks formed.
	(*c*) Brown	....do	Two new cracks opened.

B.—BACK SIDE OF PLATE.

Number of shots.	Maker of plate.	Protuberance.			Cracks and openings caused by the shots.
		Height.	Length.	Width.	
1	(*a*) Cammell	19	457	445	Only one crack on top of bulging, 127 millimeters long, 5 millimeters wide, 12 millimeters deep.
	(*b*) Cammell	203	483	483	Only one crack on top of bulging, 152 millimeters long, 5 millimeters wide, 6 millimeters thick.
	(*c*) Brown	.....	.....	.....	Only on surface, 12 millimeters wide; water passed through freely.
2	(*a*) Cammell	25	457	432	A crack only on top of the bulge, 203 millimeters long, 5 millimeters wide, 12 millimeters deep.
	(*b*) Cammell	23	432	432	No more cracks formed, only on top of projection one 2½ millimeters deep.
	(*c*) Brown	38	432	432	Three cracks formed on the projection; water flows through.
3	(*a*) Cammell	35	483	457	A crack on top of projection, 280 millimeters long, 12 millimeters wide, 38 millimeters deep.
	(*b*) Cammell	200	356	470	Protuberance almost torn loose from the plate.
	(*c*) Brown	71	432	432	On the bulge three cracks are visible, greatest depth 57 millimeters; water flows freely in and out through the cracks.

All the projectiles were crushed when striking the plates, and none broke through. All the cracks on the front side only penetrated the steel layer. On the back side cracks were formed only on the protuberance. In the iron part of plate B an imperfect weld was discovered, which explains the considerable protuberance after the third shot.

The results obtained by this firing corroborate what has been said about the superficial cracks in the steel layer and their influence on the quality of the plate. From the same may also be understood what a small influence the covering plate of steel used by Brown has on the power of resistance of the armor. This cover only protects the armor from the forming of superficial cracks, without thereby increasing its absolute strength.

The 203-millimeter compound plate (Fig. 18, Plate II): This plate was the second test-plate for the armor made by Cammell & Co. for the Chinese iron-clad corvette built in Stettin. It was tested in August, 1881, on Kummersdorf field, with three shots (marked on drawing 1, 2, 3). The remaining six shots were fired at the plate in April, 1882, for artillery purposes. At these tests the fire was delivered by a 17-centimeter gun from a distance of 30 meters.

Details of trial.

Number of shots.	Weight of projectile.	Weight of charge, prismatic powder.	Striking angle.	Striking velocity.	Striking energy in metrical tons per 1 centimeter of circumference of projectile.	Penetration of projectile.	Type of projectile.	Remarks.
	Kilos.	*Kilos.*						
1	53.5	12.8	90°	466.1	11.03	The plate was not pierced	Gruson chilled iron	The projectile was shattered; no cracks; protuberance 20 millimeters.
2	.....	.....	.....	461.6	10.82	.....	.....	The same; protuberance 30 millimeters.
3	.....	.....	.....	465.4	11.00	.....	.....	The same; protuberance 20 millimeters.
297	60.29	14.5	.....	448.9	11.40	The projectile penetrated the plate.	Krupp cast-steel	The projectile was not injured; superficial fissures were observed on the plate.
298	.....	13.5	.....	421.20	10.01	Shot did not penetrate	.....	The projectile broke, the pieces remaining in the plate; no cracks were visible on the plates.
299	53.5	17.0	.....	520.0	13.7	.....	Gruson tempered	The projectile was crushed; a few superficial cracks were formed.
300	56.0	14.8	.....	460.0	11.2.	The projectile entered 30 millimeters into the target.	Gruson experimental projectile.	The body of the projectile was shattered, but the points remained whole. On the plate a few slight fissures were opened.
301	56.0	16.3	90°	489.3	12.7	The plate was not penetrated	do	Same as by shot 300.
304	60.3	17.5	65°	499.0	14.1	The projectile was found between the plate and the wooden target.	do	The projectile was shattered.

The 254-millimeter compound armor plate was tried in Portsmouth in February, 1883, as test-plate for the inspection of the armor delivered by Cammell & Co. for the Imperieuse. The stipulations for the test were: 26-centimeter gun, Palliser chilled projectile of 181 kilograms weight; charge of powder, 317 kilograms; distance, 9.15 meters; velocity of projectiles, figured, 415 meters; distance between striking-points of projectiles, 610 millimeters. The result of test was as follows: All shots were

crushed when striking. Only their points remained in the plates. On the front side a few cracks were formed, which, however, only penetrated the steel layer. Between the striking-points the steel became scaly on the surface. Only one of the cracks went through the entire thickness of the plate. It was 23 to 25 centimeters long, measured from the edge toward the interior, on the back side. The plate bulged out, without showing the slightest crack. The dimensions of the protuberance were, after the first shot, height 32 millimeters, diameter 51 centimeters; after the second shot, height 48 millimeters, diameter 61 centimeters; after the third shot, height 57 millimeters, diameter 61 centimeters. Considering the severe conditions for the test, it may be said that the results were splendid. The fact that the steel scaled between the striking-points must be counted amongst the unwelcome features, which deserve a closer attention. This plate did not show any parting of the fibers of the iron layer. The peeling off of the steel took place in the middle, within the circle circumscribing the triangle formed by the striking-points. This scaling off may be compared to the similar occurrences observed on the iron parts. In this case the peeling off appears at the edges of the plate, as, for instance, on the 30.5-centimeter thick plate tested in St. Petersburg. The insufficient number of known experimental results does not justify a decisive verdict, but from the available facts may be conjectured, that the composition of the steel, Analysis No. 3, page—, and also the circumstance that only 4 bolts were used to fasten the plate to the target, were the principal causes of this phenomenon.

The 229-millimeter compound plate was tested in Portsmouth, as inspection plate of Cammell & Co.'s order for the armature of the Collingwood. Three shots from a 23-centimeter and 4 shots from a 25-centimeter gun were fired at the plate.

Result of tests.

No. of shots.	Size of guns	Charge of powder.	Projectile.	Penetration of shot.	Protuberance.		Remarks.
					Height.	Diameter.	
	Centimeters	*Kilos.*		*Millimeters.*	*Millimeters.*	*Centimeters*	
1	23	22.6	Palliser...	113	13	49	The projectile was crushed; five superficial flaws were formed; no fissure on the protuberance.
2	23	22.6	....do	124	13	51	The projectile was shattered; four more shallow clinks were made; no fissure visible on the protuberance.
3	23	22.6	....do	124	13	51	The projectile was crushed; a few fissures were formed, greatest depth 144 millimeters; no crack on the protuberance.
4	25	31.7	....do	112	10	40	On the steel surface two cracks were observed; projectile crushed; protuberance free from cracks.
5	25	31.7	....do ...	Not determined.	16	61	The projectiles were crushed; the points remained in the plate; the protuberances were whole; all the cracks on the front side only penetrated the steel, with the exception of one, which was 140 millimeters deep.
6	25	31.7	... do ...		19	53	
7	25	31.7	....do ...		19	51	

The 305-millimeter compound armor plate (Fig. 19, Plate II) was made by Cammell and tried in St. Petersburg. The fire was delivered from a 28-centimeter gun, with chilled shots and the following charges of powder: First shot, 66.4 kilograms; three following shots, each, 40.8 kilograms of powder. The velocity of the projectile was at the first shot 497 meters, and the other three shots 355 meters The results of the test may be seen by the drawing. The projectiles were crushed, though their points remained in the plate, so that, with the exception of second shot, which entered 114

injurious to a steel plate than to a compound plate. They must, therefore, be given the closest attention. The plates may crack, in the first place, in any direction; in the second, also, a long time after the plate is finished. This latter circumstance is of very great importance, as it makes it impossible to ascertain the good quality of a steel plate by tensile tests, but only by firing. There can be no conclusion drawn from the quality of the test plate as to that of the other plates. The third shot was fired with a charge of powder of 66.4 kilograms and a steel projectile from Obuchow steel works. The shot went through the plate and the wooden underlayer, flying 640 meters out in the field, without suffering the least change. On the drawing is shown only the point against which the shot was directed. The plate was entirely destroyed, and the piece B fell from the target. It is not to be supposed that the plate parted when the shot struck, affording it passage through the wooden layer; on the contrary, there appeared on the pieces of plate where the shot struck them circular notches corresponding to the size of the projectile, and visible throughout the thickness of the plate. The surfaces of these notches were tempered blue from the heat, created by the penetration of the shot, and from the oxidizing influence of the air. The chemical composition of the steel in the plate was, C. 0.410 per cent.; Si. 0.067; S. traces; P. 0.057; Mn. 0.288 per cent.

TRIAL OF 48 CENTIMETERS THICK COMPOUND AND STEEL ARMOR PLATES AT SPEZIA, IN OCTOBER, 1882.

(Figure 21, Plate II.)

A minute description of these tests is given in the "Mittheilungen aus dem Seewesen," volume 1882, page 675.

The purpose of these trials was to decide which of these plates had the greatest power of resistance. The Italian Government intended, on the bases of the experience gained from these trials, to select the type of armor plates for the turret-ship Lepanto. The test was made with a 100-tons heavy muzzle-loading gun. The charge was accordingly proportioned. The shot, Gregorini chilled-cast iron; weight, 907 kilograms. All the trials were made under the same specifications. The only difference was that the steel plate, though of the same dimensions as the compound plates, was fastened to the wood backing by 20 bolts (the diameter of bolts, 114 millimeters; depth of thread in plate, 63 millimeters). The compound plate was held only by 6 bolts (diameter of bolts, 114 millimeters; depth of thread in plate, 140 millimeters), into which the bolt was screwed 114 millimeters deep. As the way of fastening the plate onto the wooden target has a great influence on the result of the firing, the reader's attention is called to the distribution of bolts. The bolt-holes in the steel plate are shown by Fig. 22, Plate III, and in the compound plate by Fig. 23, Plate III. It is known that the Italian navy department, before the plates were shipped to the place of trial, sent the manufacturer's drawings of the armor plates, on which the points were marked towards which the projectiles were to be directed. In addition, it was stipulated that only three vertical rows of bolts were to be used. The drawing of distribution of bolts on the steel plate indicates that the arrangement of holes was very

unsymmetrical, evidently adapted to the designated striking points. It was plainly modified especially to suit the peculiarities of the plate, which we may suppose had been thoroughly studied. It can hardly be doubted that, had the maker of the compound plate better studied the characteristics of their plates and adopted a method of fastening more suited to these characteristics, even they would have abandoned the old distribution of bolts and manner of fastening, and this so much the more as the plate most necessarily must be so fixed on the target that it is secured against falling down as long as possible. The drawings show that the English makers had not studied such heavy compound plates with sufficient thoroughness, and therefore fastened them to the target with only 6 bolts in two horizontal rows, which fastening, as the experiments proved, was entirely insufficient.

The results of the testing of the 48-centimeter armor plates follow:

(*a*) *Cammell & Co.'s plate.—First shot:* The projectile struck the plate on the designated point with an energy of 6,390 meter tons. The body of the shot was crushed, only the point remaining in the plate. The plate suffered the following injuries: The piece A was torn loose from the wood backing. A few concentric fissures, which on the drawing are marked A A A, were formed. The depth of penetration of the shot was not measured, as the top piece remained in the plate. From the diameter of this piece, which only measured 127 millimeters, it may be concluded that the depth of the penetration was insignificant. It must be noted that the penetrating fissure which caused the breaking loose of piece A did not go through the center of the striking place, but only touched its circumference. *Second shot:* The projectile, which struck with an energy of 10,528 meter tons, did not penetrate the plate, and caused only a shallow cavity, but the plate was, however, entirely destroyed; several penetrating cracks opened, meeting at the striking point, and all the pieces of the plate fell from the target. The drawing shows the plate, as if it still remained on the target; that is to say, it shows all the pieces so as they no doubt would have been hanging on the target had a sufficient number of bolts been used.

(*b*) *Brown & Co.'s plate.—First shot:* The projectile had when striking an energy of 6,420 meter tons. It made only a small cavity in the plate, in which remained the point of the shot. The diameter of the point was 63 millimeters. The projectile was crushed. The concentric fissures A A A, which penetrated the steel layer, and a few superficial flaws, were caused by the shock. *Second shot:* The projectile, striking with an energy of 10,512 meter tons, was crushed to pieces, making only a slight mark on the plate. This was, however, destroyed; only the piece B remained hanging on the target.

(*c*) *Steel plate from Creuzot.—First shot:* The projectile, which struck with an energy of 6,525 meter tons, was crushed. No chinks were visible on the plate. The point of the shot remained in the plate, and it was found that, though the diameter at its base was only 165 millimeters, the point had entered 216 millimeters deep into the plate. The shot struck under an angle of 10 degrees to the vertical. *Second shot:* As by all the other tests, with the exception of the one next previous, the projectile struck the plate at right angles. It had an energy of 10,385 meter tons, and did evi-

dently go deep into the steel, as the remaining part was 46 centimeters in diameter, measured across the plate, and without counting the surrounding edge. . The plate received several penetrating fissures going through the striking point, but all parts remained hanging on the wooden target. As any further comparative test was impossible, the results of the third shot are not recorded. It is, however, stated, that even after the third shot about 75 per cent. of the plate remained hanging on the target. Though even the woodwork seemed somewhat shattered, the shot did not penetrate, but fell, with a piece of the plate, in front of the target, where it was found considerably changed in form (Fig. 24, Plate III). It was a steel projectile, from Terre Noire works, had an original length of 1,130 millimeters, and was upset to 710 millimeters by the shock against the plate.

Table giving weights of powder-charges and shots used at the comparative testing of 48-centimeter steel and compound plates, velocity of projectiles, and other data referring to the destructive effect of the shots.

Number of shot.	Maker of plate.	Weight of powder-charge.	Weight of projectile.	Striking velocity.	Striking energy of projectile.		Thickness of iron plate penetrated by a similar charge.
					Total.	On one centimeter of circumference of projectile.	
		Kilograms.			*Meter tons.*	*Meter tons.*	*Centimeter.*
1	Compound Cammell	149	917	371.5	6,390	45.3	49.—
	Compound Brown	149	917	372.5	6,420	45.6	49.—
	Steel Creusot	199	917	375.5	6,525	46.3	49.5
2	Compound Cammell	217	917	477.0	10,528	74.8	64.—
	Compound Brown	217	917	476.6	10,512	74.6	64.—
	Steel Creusot	217	917	474.0	10,385	73.8	62.5
3	Steel Creusot	217	942.5	468.8	10,565	75.—	64.—

Chemical composition of the steel in the 48-centimeter armor plates, according to analyses made in France.

MAKER AND KIND OF PLATE.

	Cammell compound.	Brown compound.	Creusot steel.
	Per cent.	*Per cent.*	*Per cent.*
C	0.90	0.78	0.41
Si	0.28	0.17	0.067
P	0.065	0.065	0.027
Mn	1.8	0.98	2.88

Table giving the results of physical tests on iron and steel bars, taken from the 48-centimeter armor plates after the artillery test.

[These tests were made by the Italian naval authorities.]

Kind of plate and test pieces. Particulars of tests.	Compound plate from Cammell.			Compound plate from Brown.			Steel plate from Creuzot.		
	Steel, lengthwise.	Iron. Along the fiber.	Iron. Across the fiber.	Steel, lengthwise.	Iron. Along the fiber.	Iron. Across the fiber.	Lengthwise.	Crosswise.	Through thickness of plate.
Dimensions of test pieces in millimeters and square millimeters:									
Diameter	20	20	20	20	20	18.8	20	20	20
Area	314	314	314	314	314	278	314	314	314
Length	100	100	100	100	100	100	100	100	100
Load in kilograms per square millimeters of area of test piece.									
Temporary and permanent elongation in millimeters:									
Load	.....	12.5	13.5	.....	15.5	.....	34.5	32.0	35.5
Temporary elongation	.....	0.05	0.05	.....	0.05	.....	0.05	0.05	0.05
Permanent elongation	.....	0.00	0.00	.....	0.00	.....	0.00	0.00	0.00
Load	.....	17	17	.....	.....	.....	37.5	39.5	40.0
Temporary elongation	.....	2.5	1.4	.....	.....	.....	0.5	2.0	1.0
Permanent elongation	.....	2.0	1.4	.....	.....	.....	0.0	1.0	0.6
Load	.....	22	22	.....	22	.....	45.5	47.0	.....
Temporary elongation	.....	5.2	5.2	.....	3.0	.....	2.8	6.0	.....
Permanent elongation	.....	4.7	4.3	.....	2.7	.....	2.0	5.2	.....
Greatest load square millimeters of area of test piece and elongation of the same in per cent. of its length:									
Load	.....	27.5	28	64	28.5	33	66	58	45
Elongation, per cent	.....	14.5	15.	2.3	13.	14.	14.	15.	3.2
Load in kilograms per square millimeters of area of test pieces	47	24.5	26	64	27	32	54	50	45
After rupture:									
Elongation in per cent	0.00	17.3	18.	2.	17.	19.	20.	23.5	3.
Diameter in millimeters	20	18	18	19.9	18.5	18.	15.5	14	19.6
Area in square millimeters	314	254	254	311	269	254	188.6	154	302
Proportion of areas before and after rupture	1.0	1,236	1,236	1.01	1.17	1.09	1.66	2.04	104

The above table shows the excellent quality of the test pieces from the 48-centimeter steel plate from Creuzot. In spite of these it cannot be ascertained from the result of the firing tests that the steel plates were superior to the compound armor made by English manufacturers for the Lepanto, and tested at the same time. Already in 1876 a 55-centimeter steel armor plate was tried in Spezia, thus at a time when yet no compound armor plates existed. The compound plates tried in Spezia in October, 1882, possessed further, as shown by the table, no very good physical qualities. They therefore did not represent the quality which nowadays can be reached in compound armor. The steel bars from the Creuzot plate were in all cases taken from the back part of the plate, that is, from the part that corresponds to the wrought-iron layer of the compound plate. We have seen that the elongation of this material in no case exceeded 32½ per cent. for a test piece of 10 centimeters, which shows that if the steel had been softer, and accordingly lower in carbon, the firing test might have given a still better result. It is known, however, from the experience gained in testing other steel armor, that soft plates, low in carbon, under fire receive penetrating cracks. The steel in the Creuzot plate cannot be considered of very soft quality, when the great reduction of area at the breaking point is taken into consideration. The area is the dimension, which ought to serve for determining the toughness of material when trying metals by tensile tests in bars of

regular shape, the area being a more correct standard than the elongation of the test piece only. As the plates made exclusively out of steel always deserve a great deal of interest, drawings have been shown (Figs. 25, 26, 27, 28, 29, Plate III), from which can be seen the results of tests of four steel plates 40 to 50 centimeters thick, intended for the French iron-clad the Terrible. These plates represent the best Creuzot armor exposed to firing test. The trials were made in Havre under the following specifications: Breech-loading gun, 32 centimeters; charge of powder, 67.3 kilograms for first and second shot, and 72 kilograms for third shot; velocity of projectile, 436 millimeters and 456 millimeters, respectively; weight of shot, 344 kilograms.

The Italian navy department has, in consequence of the experience gained by the comparative trials in Muggiano, in November, 1882, changed the specification for testing compound armor for their large iron-clads. In the latter part of September, 1883, plates for the armor of the Italia were subjected to artillery test according to the new specification. For firing, a 100-ton muzzle-gun was used. It may be proper to add to this paper a description of these latest trials of armor plates of great thickness and recent make. The drawings (Figs. 29 and 30, Plate III) of the tested plates are made from photographs. Benefiting by the experience with insufficient fastenings for 48-centimeter compound plates at Muggiano, November, 1882, each plate was this time secured to the 80-centimeter thick wood-work by 16-114 millimeter bolts, which entered 114 millimeters deep into the plate. The 48-centimeter plate, from Cammell & Co. (Fig. 29, Plate III), was fired at with a 100-ton muzzle-loading gun from a distance of 93 meters, standard, 912 kilograms' chilled Gregorini projectile, and a charge of 217 kilograms Fossano powder. The initial velocity of the projectile was 477 meters; the velocity when striking, 417 meters; the energy developed when striking, 74 meter tons for every centimeter of the circumference of the projectile. The shot went in about 22 centimeters deep. Radial fissures opened on the plate, but no piece of the same was broken loose.

The plate from Brown for protecting the Italia's redoubt was only 45 centimeters thick. The charge of powder was therefore correspondingly reduced. The weight of the chilled Gregorini shot was 915 kilograms; the charge, 196 kilograms of Fossano powder; the initial velocity of the projectile was 452 meters; the velocity when striking, 449 meters; the energy, when striking, per centimeter of circumference of projectile, was 65 meter tons. The shot entered 21 centimeters deep into the plate. Radial fissures were opened.

CONCLUSION.

The idea of armor of the so-called compound type, that is, made out of iron and steel combined, is very rational. The compound plates owe their existence to the idea of Mr. Alexander Wilson and the works of Cammell & Co., who bought his patent. The right to use this patent was secured by Dilligen in Prussia (see "Eisen und Stahl," No. 2, 1882) and by the works at St. Chamond, Chatillon, and Commentry, and Rive-de-Gier, in France. Brown & Co.'s works own the patent of J. D. Ellis, and make their plates after his method.

The projectile strikes the facing steel layer, which possesses a considerable hardness and presents a great resistance to penetration. The steel is at the same time

most intimately connected by welding with a tough and thick underlayer of iron. The resistance of the steel so changes the shape of the shot that it is unable to penetrate the plate, and that almost its whole energy is spent on destroying itself. Most projectiles are crushed to pieces. The present standpoint of the metallurgical science makes it possible to weld steel to iron. Thus an armor is produced having a hard facing surface, which resists the penetration of the shot, while the underlaying soft-iron part forms a cushion for the steel. It is easier to make such a plate than to reach the same results by subjecting a single steel plate to various processes, such as tempering and annealing of one side to give different hardness and elasticity to different parts; this is what has been tried at Creuzot. The compound plates possess a special advantage in their toughness, secured by the layer of fibrous wrought iron. Owing to this quality, compound plates, when thoroughly secured in place and subjected to firing test, only receive cracks, running through the steel part, while even the best steel plates, when tried by fire, are fractured from side to side. The present method for making compound armor, if also well planned and rational, is still far from perfect in its application; and though the present compound armor offers a better protection than the iron plates, and is safer than the steel armor, still many improvements in the methods of working might be introduced, pointing as well to better materials as to improvements in manufacture of the plate. It is especially important that the welding of the steel to the iron layer is perfect, and that the steel part of the plate forms one solid, homogeneous mass of metal. As indicated by all the tests, the plates do not, however, possess these two qualities in a desirably high degree. That the plates, when tested by fire, show good qualities is not sufficient reason for declaring them perfect. By special tests their defects can be discovered, and it depends on the smaller or greater number of deficiencies what degree of perfectness is to be credited to the plate. In the interior of compound plates manufactured according to the present method are often found conglomerations of blisters flowing together. Other plates are found the material of which, in consequence of the great number of small blisters, looks spongy. Facts like these are liable to alarm persons who, without being particularly familiar with compound armor plates, are for the first time called upon to express their opinion. Though this alarm may not be entirely without cause, the impossibility to avoid the defects has prompted the English Admiralty to accept blistered plates. At any rate, large blisters must be injurious to the plates, as there must be a difference, whether each centimeter of the area of the projectile strikes against a homogeneous, solid, or a porous, spongy mass of metal. The former always consumes for its destruction more energy from the striking projectile per cubic centimeter of volume than the honeycombed plate, especially if the shot should strike a larger cavity. The interior strains in the steel layer, which, with the present mode of manufacture, are impossible to avoid, and the large blisters are still more injurious to compound plates. If no blisters were found in the steel layer this could be tempered and considerably reduced in thickness. At the same time the iron part might be proportionately increased. This would be of great advantage for heavy plates—for instance, like those 48-centimeters tested at Spezia—as the experiments have shown that in these plates the 305-millimeter iron plate was inadequate to resist the shock which the plate received when struck by

a shot with the energy of 10,540 meter tons, and to prevent the fissures which momentarily after the striking of the shot appear on the surface of the plate. These fissures are certainly rather common on all compound plates after firing tests, but they were particularly numerous in this case, where the iron part was unusually thin. On account of the possible presence of blisters, however, there is no use thinking of tempering or reduction of thickness of the steel. Only ignorance of facts can lead to experiments in this direction. The impossibility to avoid these defects explains why blisters in the plates are tolerated. The problem is, however, how to reduce them to a minimum, and how to avoid them, as well as the other deficiencies mentioned. The same means which promote the welding of the steel to the iron also serve to prevent the formation of blisters. If succeeding in the one, the other is also promoted. As the perfect welding is most important in the compound plates, the means for promoting the same possess a great value for the manufacture of this class of armor. It is peremptory for the quality of compound armor, as far as toughness and strength against rupture are concerned, that the iron portion is made out of the most perfect material. It may, therefore, be considered that the armor is the nearer perfect—first, the harder (higher in carbon) and more homogeneous the steel facing is; second, the softer and tougher the iron part; and, third, the more perfect the weld between the iron and steel. On the other hand, it has also been demonstrated that the harder the steel used in the pile is, thus the greater the difference in metallurgical composition between the steel and iron parts, the more injurious to the completed armor is the effect of the finishing in the rolls. By the rolling, interior strains are caused, which frequently, soon after the plate is finished, show their presence, even on very small provocations. For instance, rough handling during the transport, uneven heating, or when exposed to severe frost. If the plate is not rolled sufficiently hot the toughness of the iron part is reduced. In compound armor plates interior strains are always present. We so far have employed no means for neutralizing these. As a consequence, lots of fissures open when the plate is tested by artillery, frequently already after the first shot. This defect might be avoided if it was possible to anneal only the steel layer. This has been proven on plates which were reheated for bending. Up to date it is not finally settled which type of compound armor deserves absolute preference. Whether it is better to overlook great internal strains in the steel layer, and choose plates with hard steel slab, liable to many fissures, or to prefer plates with comparatively soft steel cover, or plates which, by special operations, have had their steel layer at least partly freed from its tendency to crack. As frequently stated, improper rolling, especially the heating, has a very injurious influence on the iron part of the plate. The insufficient and narrow firing test for compound plates does not give sufficient facts to decide which of these two kinds of armor deserves the preference. As a rule the cracks only extend through the steel layer. At least such has been the case with all (recently manufactured) compound plates of up to 30.5 centimeters thickness. The penetrating cracks which appeared on the 48-centimeter compound armor tested at Spezia were probably caused by the too great thickness of the steel compared to the iron; therefore, the defects adherent to the steel also appeared more pronounced. The question under discussion is, therefore, also of great importance in regard to very heavy com-

pound plates. Compound armor plates show characteristics differing from those of iron; it therefore seems necessary to test them in a different way. To direct the projectile at right angles against the plate, and to select a test plate of small dimensions, as has hitherto been done, does not suffice. Such tests merely show that compound plates offer a much greater resistance than plates made of wrought iron only. It would, however, be very important to be able to determine how the interior strains are changing in a plate of the length and width ordinarily used in the armor of men-of-war when struck by a projectile. The pieces of armor at present tested by firing are usually only 2 to 3 meters long and 2 meters wide, and thus considerably different from the plates in the armor; therefore, the effect of the shot must be decidedly different. Without doubt the projectiles ought to be directed to strike the plate obliquely as well as at right angles. The striking points ought to be located not only in the middle but near the edges of the plate. If tests are carried out in such a manner, correct facts would be obtained to bring nearer its solution the question, Which kind of compound armor is to be preferred?

FLOATING BATTERIES.

BY COMMANDER W. T. SAMPSON, U. S. NAVY.

Appendix to Report of Committee No. 5, Board on Fortifications or other Defenses.

Floating coast defenses may be divided conveniently into (1) floating batteries, (2) gunboats, and (3) torpedo-boats, the essential difference between the first two consisting in the size and amount of protective armor. The distinctive features of a floating battery, as compared with a sea-going vessel, are that the former should possess the maximum powers of offense and defense, with the least practicable draught and displacement. Great speed and the ability to keep the sea for any considerable time are relinquished in the floating battery in order to secure the important qualities of light draught and handiness which belong to a small vessel.

The modern sea-going ship, on the other hand, should possess high speed and great endurance, and with these must be combined offensive and defensive power, according to the duties expected of the vessel.

It is, therefore, much easier to combine in a single vessel the qualities required in a floating battery than it is to secure the necessary qualities of a sea-going ship. Indeed, so impracticable is it to combine in one vessel high offensive and defensive powers, together with great speed and endurance, which are only the main requisites in a sea-going ship, that it is no longer attempted; but certain qualities are sacrificed to secure some other in the greatest degree of excellence, and for special purposes, as when defensive power is sacrificed to speed, or when endurance is given up to secure speed or defensive power, or these combined.

As a result of this differentiation of qualities, we have:

(1) The unarmored cruiser, which as a class has several subdivisions, according to the general or specific duties required of it. This vessel has high speed and great endurance, to which moderate battery power and defensive power are added.

(2) The belted cruiser, which is a vessel of greater displacement, and therefore is capable of carrying a limited amount of protective armor, which enables it to meet on equal terms many of the older iron-clads.

(3) The sea-going iron-clad, to which is given great displacement, to enable her to carry the heaviest guns and armor. This class also comprehends many subdivisions, which result from the various duties required of the vessel or the degree of effi-

ciency aimed at. While vessels of these different classes, and other smaller kinds not included in either of these classes, are considered essential to a well-developed modern navy, none of them is, however, the best type for coast-defense vessels.

Floating batteries should have advantage over any vessels carrying the same guns which may be sent against them. Such an advantage would be secured were they of lighter draught, enabling them to work over shoal water where the enemy could not follow. In such case they would be secure against ramming and probably against Whitehead torpedoes. Such an advantage would also be possessed had they greater maneuvering power, enabling them to take positions of advantage; and this would be secured by having smaller vessels than those of the enemy, and fitted with twin screws. The floating battery should then mount guns equal or superior to any that could be sent against her; she should have protective armor of greater thickness than any probable enemy; while she should be, at the same time, a smaller vessel and of lighter draught.

To the efficient defense of a coast, it is important to be able to act offensively when opportunity offers, or when an advantage would be thereby gained. A blow struck at such a moment may be decisive, while to be powerless to follow up the effect of a repulse by the fortifications would permit the enemy to recuperate and renew the attack, or at least to withdraw when they might have been destroyed. If, during an attack, one or more of the enemy's ships takes the ground, or otherwise becomes temporarily disabled, a prompt attack by floating batteries may be able to completely disable or even destroy them. An enemy's fleet will attack a fortified position with confidence if they know that they have only to withdraw in case they are worsted, and that there will be no danger of further injury beyond the range of the forts. A hostile fleet arriving off any one of our large ports defended by forts and mines (stationary defenses) could deliberately plan and try one method of attack after another. They could concentrate their efforts upon one point, or divide the fleet and attack several points at the same time; and they could make the attack either during the day or night. If, however, the stationary defenses are supplemented by smaller floating batteries and torpedo-boats, the enemy must be much more circumspect, even when he is in full command of all his resources; and his position becomes critical if, from stress of weather or other cause, any portion of the fleet loses the support of the remainder. A night attack becomes hazardous in the extreme. He must withdraw far from the coast during the night to prevent surprise from torpedo-boats. He must, at all times, have assembled a force superior to that which may at any moment emerge from the port to attack him. It therefore appears to be desirable to supplement the land defenses by such floating defenses as will make the approach of an enemy more hazardous, and restrict his demonstrations to the narrowest limits possible. While such floating defenses may not materially augment the statical defenses of the place, their presence forces the enemy to make more extensive preparations for a given attack, requires a larger force, and greatly increased caution. In this indirect way the floating defenses add largely to the resisting power of a given locality. This may be considered the passive influence of floating defenses; but they may play, also, an important active part, under circumstances which are adapted to their peculiar functions, and which

(2) Where the great width of the approaches to the place to be defended renders it impracticable to reach all points of such approach with an efficient fire from guns on shore.

(3) In places where, from the nature of the ground, as at the mouth of the Mississippi River, it is impracticable to mount heavy guns in forts.

While these cases admit of little doubt, and should be first provided for, it appears advisable to employ them in other cases as well, for reasons before stated.

It is a matter of some difficulty to decide which of our important ports would come under either or any of the above cases. It seems evident that New Orleans should be entirely defended by floating batteries, torpedoes, and submarine mines, because of the engineering difficulties to be encountered in placing heavy guns upon such yielding foundations as exist at the mouth of the Mississippi River.

In the first of the three cases cited, where floating batteries should be employed, the application of the rule will depend upon the range of guns mounted on board ship. For it is evident that in order to properly defend a city the vessels of an enemy should not be permitted to approach it within the extreme range of his guns, without coming within destructive range of the guns forming the defense. A city forms a large target, and when it can be reached by a fire of heavy shells, its destruction is certain. A vessel, on the other hand, forms a small target; and when it is heavily armored and in rapid motion, it can be injured only at short range. It therefore becomes necessary at the outset to decide upon what may be considered the extreme range of guns mounted on board ship. The range of the heaviest high-power guns has been estimated probably with considerable accuracy and may safely be taken as 10 miles. As this extreme range is secured only at considerable elevation, thus making the energy of the recoil in a vertical direction very great, ships are probably not constructed now to withstand such great strains, and consequently could not avail themselves of the extreme range of their guns. Yet there is no reason why vessels should not be so constructed, while a wise precaution would lead us to take it for granted, and even anticipate, a large increase in the range of the guns of the future. Assuming that an armored vessel cannot maintain her position for any considerable time within 2 miles of the heaviest guns mounted in forts, it would appear that a city would be, theoretically, perfectly defended if the defenses were 8 miles in advance of the city. The attacking vessel would then be compelled to remain at a distance of 10 miles. Applying these considerations to the case of Boston, it will be seen that if heavy guns are mounted on the outer islands of the harbor and at the east point of Nahant, there would still remain a small space in Broad Sound, within 6¼ miles of Boston state-house, which would be more than 2 miles from any guns mounted on shore, yet only a little more than 2 miles, and the margin being so small in this case that the city might be considered as well defended if proper defenses were erected on shore. On the other hand, in foggy weather, to which that part of the coast is subject, the enemy could enter Broad Sound to a point within 6 miles of Boston state-house. A fog would not prevent the approach of the enemy, nor would it materially interfere with the destructiveness of his fire.

The city of Portland, although a place of secondary importance, and therefore not requiring such complete defenses as Boston, could be approached by a hostile fleet to within six miles, the fleet remaining at a greater distance than two miles from any possible fortification.

Narragansett Bay could be completely defended by forts, only at great cost; and the city of Newport is within easy range, from deep water, without entering the Bay.

New York City can be satisfactorily defended, if the outer defenses are placed at Sandy Hook, the Dry Romer, and Coney Island. But it is very doubtful if an enemy could be prevented, by the same defenses, from shelling the city of Brooklyn.

The cities of Philadelphia, Washington, and Baltimore, owing to their great distance inland, are easily defended; but Chesapeake Bay can readily be held by an enemy's vessels, in spite of any fortifications, thus putting an end to all the commerce of that great bay and the rivers which flow into it.

Charleston is another case where the outer defenses must be within five miles of the city, leaving an enemy to approach within eight miles of the city, and in deep water.

Savannah, like Philadelphia and Washington, can be easily defended.

Pensacola navy-yard cannot be defended, except by a naval force; and, without delay, it should be abandoned as a naval station.

Galveston is even more difficult to defend.

As for San Francisco, it would not be easy to employ mines in the defense of the entrance to her harbor, owing to its great depth of water and to the strength of the currents. The city itself is within easy range of heavy guns for a considerable distance along the coast.

Now, the efficiency of a gun mounted on shore is, within its effective range, much greater than if mounted afloat. It has a perfectly steady platform, and it may be protected, together with its crew, to any desired extent, thus securing deliberation and precision in its service. A gun mounted on board a floating defense may thereby have its effective range virtually increased many fold. In other words, it may be moved quickly from place to place, and perform its duty in each place, thus, in a sense, becoming equal to many guns mounted upon a stationary platform. However, the first cost, maintenance, and vulnerability of floating defenses leave the advantages in favor of the shore-mounted gun. It is, therefore, deemed best that the use of the floating batteries should at first be limited to the three cases above enumerated in any scheme which has for its object the defense of the coast, without any element of active offensive operations beyond the immediate locality. In other words, such floating defenses should be considered as a part of the stationary defenses of the country and not as a part of the Navy. As far as possible each floating defense should be adapted to the particular place of which it forms part of the defenses. It should be constructed, indeed, to take advantage of the peculiarities of the location.

In the case of all such floating batteries, endurance and speed may be sacrificed to secure the maximum offensive and defensive powers as a coast defender. It is not necessary that such a vessel should have large capacity for either coal or provisions,

for she may be supplied with either daily, if necessary. Great speed is not necessary, because she is to maneuver in a contracted space where high speed would not be attempted. The sacrifice of these qualities, speed and endurance, renders it possible to give the vessel less draught of water, and this is a great advantage where the harbor contains shoals. At the same time it becomes possible to give the vessel heavy armor and powerful guns.

Having these general principles in mind, four types of vessels have been designed.*

The largest type, of 7,000 tons displacement and carrying two 16″ guns in a turret and one 10″ gun in barbette, is intended for the mouth of the Mississippi, where she must constitute the main defense, and should therefore be superior to any vessel that could be sent against her. The hull is protected by a belt of steel armor 18″ thick and 175′ long, with a backing of 6″ of wood and an inner plating of 2″ of steel. The ends of this side armor are connected by athwartship bulkheads of steel, the forward one being 15″ and the after one 14″ thick, with a wood backing of 6″ and inner plating of steel 1¾″. The armor on turrets is the same thickness as side armor. The deck throughout its length is protected by a steel deck which forward and abaft the side armor is 3¼″ thick, and over the side armor is 2¾″ thick. A full description and drawings of this and the other types are given with this report.

The guns proposed for this first type of vessel are equal to any that have been constructed. Only three vessels now afloat are armed with guns of similar power, though several in England, France, and Italy are in process of construction. No vessel afloat carrying such guns is as well protected by armor as that proposed for this type of vessel, and in all cases a sea-going ship possessing equal offensive and defensive power must draw from 5′ to 8′ more water.

Referring to Table I, given at p. 11, it will be seen that of the 15 vessels possessed by England, carrying fifty guns capable of piercing 20″ or more of wrought iron, only two can enter the ports of Boston, New York, New Orleans, or Baltimore, while none of them could enter any other important port on the Atlantic coast. Any of them, however, could enter the harbor of San Francisco. Indeed, any vessel afloat may enter that harbor or the harbor of Portland, Me., Narragansett Bay, and Hampton Roads.

Of the sixteen ships possessed by France carrying guns capable of piercing 20″ or more of wrought iron, seven, carrying 18 guns, can enter the harbors of Boston, New York, or New Orleans.

The second type of vessel closely resembles the first, possessing similar qualities. Her displacement is 6,500 tons, mounting two 14″ guns in a turret and two 10″ guns in barbette, and protected by 16″ of steel armor for a length of 160′. The turrets are protected by a similar thickness, while the bulkheads are 15″ and 14″ thick. In these respects the second type is somewhat inferior to the first; but the second draws only 19′ instead of 22′ 4″, thus enabling it to maneuver over shoaler water.

This type is, in battery power, scarcely inferior to any vessel afloat, and would have most decided advantages as a coast defender over any vessel mounting similar guns that is now afloat.

* All the designs given in this report were made by Assistant Naval Constructor Richard Gatewood, U. S. N.

Upon this basis the following table shows the cost of each type of vessel complete in all respects, and the cost of the whole number estimated for each of the four localities, Long Island Sound, Hampton Roads, Mississippi Passes, and San Francisco.

Ports.	VESSELS.			GUNS.				Total cost at each port.
	First type.	Second type.	Third type.	16-inch.	14-inch.	12-inch.	10-inch.	
Long Island Sound	.....	2	2	.....	4	4	8	$11,550,000
Hampton Roads	.....	2	2	.....	4	4	8	11,550,000
Mississippi River	2	.....	.....	4	.....	.....	2	8,150,000
San Francisco	.....	3	.....	.....	6	.....	6	10,725,000
Total	2	7	4	4	14	8	24	41,975,000

COST.

First type	$4,075,000
Second type	3,575,000
Third type	2,200,000

Referring again to the natural features of the principal ports, and the practicability of defending them by forts and mines, we see that the places where floating batteries should first be employed, or the points at which it is necessary to employ them, are Chesapeake Bay, Long Island Sound, the mouth of the Mississippi River, and the harbor of San Francisco. In Chesapeake Bay and Long Island Sound the duties of floating batteries would be to prevent an enemy from taking shelter in the bay or sound, or taking entire possession and stopping all commerce, as even one or two good ships in each could do. In case of an overwhelming force attacking them, the floating batteries could avail themselves of the protection of the forts at Hampton Roads or New York. To serve the purpose of defending the bay or sound against such incursions as would be beyond the reach of the forts, it is probable that four vessels, two of the second type and two of the third in each place, would be sufficient. These, together with the necessary torpedo-boats, would render it hazardous for an enemy to attempt to enter the bay or sound, much less to attempt to maintain his position there.

At the mouth of the Mississippi the floating batteries would be entirely dependent upon themselves, and should, therefore, be of the first type, carrying the heaviest guns. Two of these would probably be more than a match for any fleet that would be able to operate against them in the passes of the river. These heavy guns would, however, have to be supplemented by lighter guns, on small vessels, for the protection of the mines; or probably this would be more satisfactorily accomplished by light guns mounted on shore for this special purpose.

San Francisco presents conditions which are not to be found in the case of any other first-class port. There the office of the floating batteries would be to sally from the port and meet the enemy upon deep water, for in no other way could they prevent the city from being shelled. To do this successfully they should be superior to any probable enemy. Taking into consideration the locality of the city in the Pacific, so far removed from those nations who maintain the great fleets of the

world, and remembering that those nations would greatly weaken their offensive and defensive powers near home by sending their best ironclads so far away, it may be assumed that three of the second type of vessels would be sufficient for the purpose.

For the partial defense of the Lakes a small vessel has been designed which can pass through the Erie Canal. The treaty existing between the United States and Great Britain prevents this country from maintaining or building a naval force upon the lakes. In case of a difficulty with that country the United States would be at a disadvantage upon the lakes under circumstances most favorable to us. The torpedo gun vessel here submitted appears to meet this difficulty as far as it is possible to do so.

The cost of this vessel, including armament and torpedoes, would be $95,000.

W. T. S.

NUMBER OF VESSELS BUILDING AND COMPLETING BELONGING TO ENGLAND, FRANCE, GERMANY, ITALY, AND RUSSIA.

[Showing number of guns carried, divided into two classes: 1. Those capable of piercing 12″ to 20″ wrought iron; 2. Those capable of piercing 20″ to 33″ wrought iron at the muzzle.]

Ports.	Draught of ships which can enter.	ENGLAND.			FRANCE.			ITALY.			RUSSIA.			GERMANY.		
		Number of ships.	Number of guns which will penetrate 12″ to 20″.	Number of guns which will penetrate 20″ to 33″.	Number of ships.	Number of guns which will penetrate 12″ to 20″.	Number of guns which will penetrate 20″ to 33″.	Number of ships.	Number of guns which will penetrate 12″ to 20″.	Number of guns which will penetrate 20″ to 33″.	Number of ships.	Number of guns which will penetrate 12″ to 20″.	Number of guns which will penetrate 20″ to 33″.	Number of ships.	Number of guns which will penetrate 12″ to 20″.	Number of guns which will penetrate 20″ to 33″.
Portland	Any draught															
Narragansett Bay	do	97	589	.....	51	235	.....	18	116	.....	24	56	.....	22	65	.....
Hampton Roads	do	15	.....	50	16	.....	44	9	.....	36	0	.....	0	0	.....	0
San Francisco	do															
Boston	Less than 26′															
New York	do	72	348	.....	28	82	.....	9	28	.....	24	56	.....	22	65	.....
New Orleans	do	2	.....	4	7	.....	18	0	.....	0	0	.....	0	0	.....	0
Baltimore	Less than 25′	69	316	.....	26	74	.....	7	14	.....	19	30	.....	20	49	.....
		2	.....	4	7	.....	18	0	.....	0	0	.....	0	0	.....	0
Philadelphia	Less than 23′	61	259	.....	16	32	.....	7	14	.....	18	26	.....	18	41	.....
Norfolk	do	0	.....	0	1	.....	2	0	.....	0	0	.....	0	0	.....	0
Pensacola	Less than 21′	51	165	.....	11	14	.....	7	14	.....	18	26	.....	18	41	.....
		0	.....	0	0	.....	0	0	.....	0	0	.....	0	0	.....	0
Washington	Less than 20′	43	77	.....	11	14	.....	7	14	.....	18	26	.....	18	41	.....
		0	.....	0	0	.....	0	0	.....	0	0	.....	0	0	.....	0

ENGLAND.

Vessels mounting guns capable of piercing wrought-iron armor 12″ to 20″ thick—at muzzle.

Class.	Guns.
ARMORED VESSELS.	
Téméraire	8
Impérieuse	10
Warspite	10
Collingwood	10
Rodney	10
Howe	10
Benbow	12
Camperdown	10
Anson	10
Devastation	4
Thunderer	4
Dreadnaught	4
Neptune	6
Inflexible	4
Ajax	4
Agamemnon	4
Conqueror	6
Hero	6
Colossus	9
Edinburgh	9
Renown	15
Sanspareil	15
Sultan	12
Alexandra	12
Superb	16
Belleisle	4
Orion	4
Northampton	12
Nelson	12
Shannon	9
Orlando	12
Undaunted	12
Australia	12
Narcissus	12
Galatea	12
Glatton	2
Cyclope	4
Gorgon	4
Hydra	4
Hecate	4
Rupert	4
Total ... 41	343
VESSELS ORDERED TO BE BUILT SINCE SEPTEMBER, 1885.	
Immortalité	12
Aurora	12
Trafalgar	12
Nile	12
Total ... 4	48

Class.	Guns.
ARMORED VESSELS BUILT PREVIOUS TO 1870.	
Monarch	4
Hotspur	2
Bellerophon	12
Hercules	14
Total ... 4	32
COLONIAL VESSELS.	
Cerberus	4
Magdala	4
Abyssinia	4
Total ... 3	12
Total armored ... 52	435
UNARMORED VESSELS.	
Leander	10
Arethusa	10
Phaeton	10
Amphion	10
Calypso	4
Calliope	4
Mersey	12
Severn	12
Thames	12
Forth	12
Boadicea	12
Euryalus	12
Turquoise	4
Emerald	4
26 "Staunch" type	26
Total ... 40	154
COLONIAL VESSELS.	
Protector	1
Victoria	1
Albert	1
Paluma	1
Gayundal	1
Total ... 5	5
Total unarmored ... 45	154
Total armored ... 52	435
Grand total ... 97	589

Vessels mounting guns capable of piercing iron 20″ to 33″ thick at muzzle.

Class.	Guns.
Collingwood	4
Rodney	4
Howe	4
Benbow	2
Camperdown	4
Anson	4
Inflexible	4
Conqueror	2
Hero	2
Colossus	4
Edinburgh	4
Renown	2
Sanspareil	2
Trafalgar	4
Nile	4
Total ... 15	50

FRANCE.

Vessels mounting guns capable of piercing armor 12″ to 20″ thick at muzzle.

Class.	Guns.
Friedland	8
Trident	10
Colbert	10
Redoubtable	8
Dévastation	6
Courbet*	6
Richelieu	11
Amiral Duperré	4
Amiral Baudin	8
Formidable	8
Marceau	4
Hoche	4
Magenta	4
Neptune	4
Charles Martel	4
Brennus	4
Terrible	2
Requin	2
Indomptable	2
Caïman	2
Tonnerre	2
Fulminante	2
Furieux	2
Tempête	2
Vengeur	2
Tonnant	2
La Galissonnière	6
Victorieuse	6
Triomphante	6
Turenne	4
Bayard	4
Duguesclin	4
Vauban	4
Total 33	147
ARMORED GUN-VESSELS.	
Achéron	1
Cocyte	1
Phlégéton	1
Styx	1
Fusée	1
Grenade	1
Mitraille	1
Flamme	1
Total 8	8
VESSELS BUILT PREVIOUS TO 1870.	
Océan	8
Marengo	8
Suffren	8
Provence	8
Savoie	8
Revanche	8
Heroïne	8
Flandre	8
Surveillante	8
Valeureuse	8
Total 10	80
	8*
	80
	147
Grand total 51	235
IN ADDITION ARE THE FOLLOWING COAST-DEFENSE VESSELS, NOT INCLUDED ABOVE.	
Onondaga	4
Taureau	1
Cerbère	2
Bélier	2
Tigre	2
Bouledogue	2
Total 6	13

Vessels mounting guns capable of piercing wrought iron 20″ to 39″ thick.

Class.	Guns.
Dévastation	4
Courbet	4
Amiral Duperré	4
Amiral Baudin	3
Formidable	3
Marceau	2
Hoche	2
Magenta	2
Neptune	2
Charles Martel	4
Brennus	4
Terrible	2
Requin	2
Indomptable	2
Caïman	2
Furieux	2
Total 16	44

* "Courbet" was formerly named "Foudroyant."

ITALY.

Vessels mounting guns capable of piercing 12″ to 20″ wrought iron at muzzle.

Class.	Guns.
Duilio	4
Dandolo	4
Italia	16
Lepanto	16
Andrea Doria	16
Ruggiero di Lauria	16
Francesco Morosini	16
Sicilia	(?)
Ré Umberto	7
Palestro	7
Principe Amadeo	7
Giovanni Bausan	2
Vesuvio	2
Stromboli	2
Etna	2
Tripoli	2
Grito	2
BUILT PREVIOUS TO 1870.	
Affondatore	2
Total, 18	126

Note.—It is probable that the 6-inch guns carried by the Vesuvio and class are of the highest power, which would add 40 guns to the number under this head.

Vessels mounting guns capable of piercing 20″ to 33″ wrought iron at muzzle.

Class.	Guns.
Duilio	4
Dandolo	4
Italia	4
Lepanto	4
Andrea Doria	4
Ruggiero di Lauria	4
Francesco Morosini	4
Sicilia	4
Ré Umberto	4
Total	36

RUSSIA.

Vessels mounting guns capable of piercing 12″ to 20″ wrought iron at muzzle.				*Vessels mounting guns capable of piercing 20″ to 33″ wrought iron at muzzle.*
Class.	Guns.	Class.	Guns.	
Peter Velikij	4	VESSELS BUILT PREVIOUS TO 1870.		None.
Admiral Nakimoff	4	Admiral Lazareff	3	*Note.*—It is probable that the later guns—those mounted on the *Nakimoff*, *Alexander II*, *Catherine II*, *Sinope*, and *Tchesme*—have much higher power than is given in the tables, and that these vessels should be included under this head. The powers given are taken from the latest tables available.
Alexander II	4	Admiral Tchitchagoff	2	
Catherine II	6	Admiral Greig	3	
Sinope	6	Admiral Spiridiff	2	
Tchesme	6	Total, 24	56	
Novgorod	2			For the same reason it is probable that the *Monomach*, *Dmitri Donskoi*, *Moskwa*, *Admiral Arkass*, *Vitiaz*, *Rinda*, and *Minin* should be in adjoining list.
Vice-Admiral Popoff	2			
12 "Staunch" type gun-boats	12			
Total	46			

GERMANY.

Vessels mounting guns capable of piercing 12″ to 20″ wrought iron at muzzle.		*Vessels mounting guns capable of piercing 20″ to 33″ wrought iron at muzzle.*
Class.	Guns.	
Preussen	4	None.
Friedrich der Grosse	4	*Note.*—Although the calibers of Krupp guns on board the vessels of the German navy are known, their weights or lengths are unknown, and in order to keep within a safe limit the penetration of the early and shorter types are given.
Kaiser	8	
Deutschland	8	
Sachsen	5	
Bayern	5	
Würtemberg	5	
Baden	5	
Oldenburg	8	The long types have a penetration of 12″ wrought iron for the 5.9″ gun of 35 calibers, 23.1″ for 11″ gun, and 25.1″ for the 12″.
13 armored gun-vessels	13	
Total, 22	65	
For the reasons given in the adjoining notes it is probable that the five (5) unarmored corvettes building, mounting 72 guns of 5.91″ caliber, should be included under this head.		It is probable that the later ships are armed with the longer guns, and that the *Sachsen* class should be included under this head.

DIMENSIONS OF DRY-DOCKS (INCLUDING FLOATING AND LIFTING DOCKS) OF MORE THAN FIFTY-EIGHT FEET BREADTH IN THE PORTS OF THE UNITED STATES.

Port.	Name of dry-dock or railway.	Kind.	Location of, in harbor.	When first opened.	Material of construction.
Buffalo, N. Y	Union Dock Company	Basin			
Detroit, Mich	Detroit Dry-Dock Company No. 1	do	Foot of Orleans street		
Do	Detroit Dry-Dock Company No. 2	do	do		
Albina, Oreg	Unknown	do			
San Francisco, Cal	do	Floating			Wood.
Do	Hunter's Point dry-dock	Basin	Hunter's Point	1868	Stone.
Do	Navy-yard	do	Mare Island	Building.	Do.
Portland, Me	Dry-dock No. 1	do		1870	Wood.
Portsmouth, N. H	Navy-yard	Floating		1851	Do.
Boston, Mass	do	Basin		1834	Stone.
Do	Simpson Dry-Dock No. 1	do	East Boston	1857	Wood.
Brooklyn, N. Y	Navy-yard	do		1851	Stone.
Do	Anglo-American Company	do	Erie Basin	1866	Wood.
Do	do	do	do	1867	Do.
New York, N. Y	Great Balance Floating Company	Balance	Foot Rutgers street		
Do	New York Float Company	Ten sections	Between Pike and Clinton streets	1867	Do.
Do	do	Eight sections	do	1858	Do.
Do	do	Six sections	do	1848	Do.
Jersey City, N. J	Balman & Brown	Balance	Foot of Essex street		
Philadelphia, Pa	Cramp & Son	Basin		1876	Do.
Do	Unknown	Sectional		1854	Do.
Baltimore, Md	Columbia Dry-Dock Company	Basin	Locust Point		Do.
Do	Woodall & Co	Floating	do		
Norfolk, Va	Navy-yard	Basin	Gosport	1834	Stone.
New Orleans, La	Valette dry-dock	Floating		1868	Wood.
Do	Maine dry-dock	do			Do.
Do	Louisiana dry-dock	do			

Port.	Length over all.	Length on blocks.	Width of entrance on top.	Width of entrance on bottom.	Depth of water over sill at— High water, ordinary spring tides.	Depth of water over sill at— High water, ordinary neap tides.	Rise of spring tides.	Rise of neap tides.	Dimensions of largest vessel that can be taken at date. Length over all.	Extreme beam.	Maximum draught of water.	Maximum weight.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Tons.*
Buffalo, N. Y	350		60		10				(a)	(a)	(a)	(a)
Detroit, Mich	308		65		13							2,000
Do	360		75		11.5							2,000
Albina, Oreg	400		72		28	18						
San Francisco, Cal	210		60		20							1,500
Do	450	416	90		24	22			438	(b)	(b)	(b)
Do	529	418	78		26.5		c10		460	78	27.5	9,000
Portland, Me	425	390	80	45	23	20	17	7	400	47	f23	Any.
Portsmouth, N. H	350		90		23				350	90	23	5,300
Boston, Mass	379		60		25				354	60	25	8,000
Do	365	350	64	45	17.5	14.5	9	6	352	64	17.5	
Brooklyn, N. Y	350		66		25				350	66	25	7,500
Do	540	441	100	46	22	20	5½	3½	510	70	22	Any.
Do	630	540	85	45	25	23	5½	3½	567	56	25	Any.
New York, N. Y	330		90		18.5	13	d5	d5				Any.
Do	360	360	100	100	20	20	d5	d5	400	95	19	6,000
Do	250	250	75	75	16	16	d5	d5			14	3,000
Do	170	170	65	65	16	16	d5	d5			14	1,500
Jersey City, N. J	185		62.5		14							1,200
Philadelphia, Pa	434	400	70	47.8	21.5	20	7	5½	425	55	21	
Do	200		62		14							2,300
Baltimore, Md	504	437	85	44	23	23			g 435	50	21	20,000
Do	220		67		14				(e)	(e)	(e)	2,000
Norfolk, Va	320		60						290	60		7,000
New Orleans, La	315	315	90		16				330	42	16	3,000
Do	220	220	75	68	14				235	70	14	1,500
Do	225		75		16							

a The largest vessel on the lakes. b The City of Tokio has been docked. c Mean. d About. e Galena and class. f Three feet less at head of dock than at gate. g On keel.

GENERAL FEATURES OF A FIRST-CLASS COAST-DEFENSE VESSEL, DESIGNED FOR SERVICE IN OPEN BAYS OR DEEP CHANNELS AND TO FIGHT IN ANY WEATHER.

A vessel has been designed to satisfy the following conditions:

To carry two 16-inch B. L. R. guns, in the complete protection of a turret suitably armored and mounted high enough above water to be fought in very heavy weather. These guns to command the greatest possible train. At least one armor-piercing gun of lighter caliber shall also be carried suitably armored and mounted so that it may be rapidly worked by hand. In addition, a fairly powerful secondary battery, with suitable shield protection and well protected ammunition lead, to be also carried. A suitable installation of automobile torpedoes expelled under water to be provided, while as complete protection as possible against torpedo attack shall be provided in the hull.

Protection shall be provided by a water-line belt of 18-inch armor, of length about 60 per cent. of the length of the vessel between the perpendiculars, terminating in athwartships bulkheads of suitable thickness, and to be continued to the ends of the vessel by under-water decks not less than 3″ thick and suitably supported. Deck plating of 2¾″ to 3″ shall be worked over the belt. Armor protection for the turret base shall be provided by a turret-chamber with about 16″ armor extending to a suitable height.

In addition, the coal shall be carried as far as possible along the sides above the armor belt.

The vessel should have a maximum speed in smooth water of not less than 15½ knots under trial conditions with forced draught.

No special limitation is placed on the draught of water, but it is not desirable that it should exceed 22′ 6″.

Armored erections, such as ventilating shaft and conning tower, should be supported and give support to one another so that as little dependence as possible may be necessary on unarmored supports. They shall be located so as to interfere as little as possible with the train of the guns and present the smallest possible target.

The coal supply at the load displacement should be sufficient for a somewhat greater distance than 1,500 knots, at a speed of 10 knots in fair weather, with bunker capacity for a greater supply.

DESIGN.

The vessel designed to meet these conditions has the following principal dimensions:

Length over all	323′ 4½″
Length between the perpendiculars	303′ 0″
Beam extreme	63′ 7″
Mean draught	22′ 4″
Displacement	7,028 tons.
Freeboard to top of main deck at side over belt	10′ 11″ to 10′ 2″
Freeboard to top of main deck aft	6′ 2″ to 5′ 8″
Armored freeboard in wake of belt	3′ 2¾″ to 2′ 5¾″
Molded depth from flat keel to top of main deck beam amidships	33′ 7″

Form.—The ratio of beam to length is 1:4.78, and the coefficient of fineness on the principal dimensions, 0.5715. The area of midship section is 1,277 square feet, and the coefficient of fineness on the midship section 0.6355. The center of buoyancy is 2′ 4″ abaft the middle of length and 9′ 6⅜″ below the load water-line. The transverse metacenter above the center of buoyancy is 14′ 1⅝″ and above the water line 4′ 7¼″. Tons per inch of immersion at the load draught is 33.58.

PROPELLING MACHINERY.

To develop 5,000 I. H. P. with open stoke-holes and not less than 7,000 I. H. P. with stoke hole under pressure, or by other approved system of forcing the draught, when burning Nixon's navigation coal or its equivalent under standard conditions of smooth-water trial.

Boilers.—Sufficient boiler power to be provided for auxiliary and main engines, besides which a donkey boiler with about 25 square feet of grate shall be carried, if possible in the deck erection, capable of making steam for ordinary ventilation and lighting purposes, anchor hoisting, and derrick engines, and at least one powerful steam-pump. Apparatus to be attached to this donkey boiler for forcing its combustion whenever necessary.

The main boilers to be eight in number, of cylindrical single-ended type, 14′ 0″ in diameter, 9′ 10″ long, each with three furnaces about 42″ internal diameter, grate about 6′ 6″ long, and having an aggregate surface of not less than 550 square feet. To supply steam of 110 pounds pressure. To be placed in pairs in four separate compartments, two on each side of the middle line bulkhead, the boilers back to back at the middle line, stoke-holes fore-and-aft outboard with complete facilities for ready supply of coal to the fires. The four boilers in the two compartments on each side to be served by the same stack, the uptakes joining above the deck plating, the openings in which to be made good by armor gratings. The weight of boilers, including donkey, with water and all attachments and boiler-room fittings, not to exceed 420 tons.

Engines.—To be of three cylinder vertical inverted compound type, driving twin screws. Cylinders about 42″ and 59″ diameter and 36″ stroke. The engine driving each screw to be in a separate compartment, formed by the middle line bulkhead. The greatest care should be taken to obtain the necessary rigidity of the bearers with the minimum of material.

To have independent circulating pumps, fitted so that they may be used to remove water from the ship.

To weigh with water in condensers and all attachments, including stores and spare parts, not more than 275 tons.

Screws.—To be of steel or suitable composition, four-bladed, about 15′ 6″ diameter, or less, and of suitable pitch.

Shafting.—Hollow shafts of Whitworth, or equivalent, steel should be used.

The weight of shafting, plummer blocks, stern tubes, screws and struts, and miscellaneous not to exceed 65 tons.

Total weight.—Total weight of propelling machinery as above not to exceed 760 tons.

MAIN BATTERY.

Turret.—To mount two 16″ 107½-ton B. L. R. on port pivoted slides. As shown in the drawing, the guns are mounted to load in only one position. If, however, a satisfactory arrangement can be perfected for loading in any position without adding to the weight of the ship, it should be adopted.

Thickness of steel armor	18″
Thickness of wood backing	6″
Thickness of plating behind armor	1¼″
Depth of cellular structure	16″
Thickness of mantlet	½″
External diameter	35′ 0″
Internal diameter	28′ 0″
Height of lower edge of port above load water-line	15′ 1″
Thickness of crown	2″

A ventilating hatch with armored grating will be fitted in the center of the crown and an up draught shall be maintained in the turret to clear it of any smoke which may enter when the breech of the guns is opened.

Guns and loading gear.—The guns, 16″ B. L. R., are of the Bureau of Ordnance preliminary design, with the following general particulars:

Length	inches	511
Weight of charge	pounds	1,000
Weight of projectile	do	2,000
Weight of gun	tons	107½

The guns load in one position. A telescopic rammer to be used reaching to the half seating of the projectile. The guns load run in and elevated.

Approximate weight of turrets, guns, and gear.

	Tons.
Guns 2 by 107.5	215
Gun-slides with recoil presses, &c	50
Gun-carriages, straps over guns, &c	20
Armor, 18″	290
Bolts	20
Crown (2″), grating, hoods, &c	40
Wood backing (6″) and fastenings	11
Plating behind armor (1¼″)	25
Cellular backing and mantlet	28
Platform, armor shelf and framing below it, beams to crown, rollers and roller bases, racks, apron, locking bolts, &c., lifting presses and all gear connected directly to the turret proper	100
Total weight of turret and guns with gear	799

Ammunition for 16-inch guns.

Weight of one round with cases	pounds..	3,200
Weight of 90 rounds with cases	tons..	129
Weight of gun and magazine equipment	do...	5
Total Weight, Turrets, Guns, Mountings, and Ammunition	do...	933.0

Barbette.—To mount one 10-inch B. L. R. gun on a central pivot carriage arranged so that the gun may be handled with the greatest rapidity.

Thickness of steel armor	10″
Thickness of wood backing	10″
Thickness of plating behind armor	1″
Bolt-head castings set up above inner surface	2″
Thickness of armored wall	21″
Height of top of armor above protective deck	8′ 6″
Height of center of trunnion above load water-line	13′ 9″
Internal diameter of barbette (inner surface of plating behind armor)	17′ 3″
External diameter of barbette	20′ 9″

Gun and loading gear.—The gun to be served by ammunition hoist in the center so as to load in any position. Every possible facility to be supplied for rapidly handling the charge, projectile, and breech-piece.

The gun 10″ B. L. R. is of the Bureau of Ordnance design, with the following general particulars:

Length	inches..	329.1
Weight of gun	tons..	26
Weight of charge	pounds..	250
Weight of shell	do...	500
Estimated muzzle velocity	feet per second..	2,050
Estimated muzzle energy	foot-tons..	14,600
Approximate penetration at muzzle, in inches of wrought iron	inches..	22¼

Approximate weight of barbette, gun, and gear.

Gun with circles and all attachments	tons..	40.0
Shield	do...	3.0
Armor, 10″	do...	95.0
Bolts, paint, &c	do...	9.0
Wood backing, 10″, and fastenings	do...	10.0
Framing, plating behind armor, &c	do...	20.0
Screen and shutters	do...	4.0
Total weight of barbette, gun, and gear	tons..	181.0

Ammunition for 10″ gun.

Weight of one round with cases	pounds..	850
Weight of 70 rounds with cases	tons..	26.6
Weight of gun and magazine equipment	do...	1.0
Total Weight of Barbette, Gun, Mounting, and Ammunition	do...	208.6

General summary.—Main battery.

	Tons.
Turret, two 16″ guns and gear	800.0
Ammunition for 16″ guns	130.0
Gun and magazine equipment for 16″ guns	5.0
Barbette, 10″ gun, and gear	182.0
Ammunition for 10″ gun	27.0
Gun and magazine equipment for 10″ gun	1.0
Total weight main battery	1,145.0

SECONDARY BATTERY.

Four 57mm single-shot rapid-firing Hotchkiss cannon:

	Pounds.
Guns and mounting, 4 by 2,200	8,800
Ammunition in cases (980 rounds, 70 cases, each)	49,000
Shields, heavy, 4 by 1,500	6,000
	63,800

Three 47mm revolver Hotchkiss:

Guns and mounting (one in crow's nest)	7,000
Ammunition in cases (1,920 rounds, 80 cases, each)	24,000
Shields, 3 by 1,000	3,000
	34,000

Four short Gatlings:

Guns and mounting, rail, 4 by 400	1,600
Ammunition in cases (4,000 rounds each)	1,760
Shields, 4 by 500	2,000
	5,360

Summary.—Secondary battery.

Four 57mm 6-pounders, rapid fire, ammunition and shields	63,800
Three 47mm revolvers ....do.... do	34,000
Four short Gatlings ....do.... do	5,360
Equipment, stores and spare parts, search-lights, &c	3,000
Total	106,160
	or 47.4 tons.

VERTICAL ARMOR.

Side-armor, as per midship-section and plans:

	Feet.
Length of belt on side	174¾
Length of belt end to end of bulkhead	184¾
	Tons.
Weight of side armor, 18″, each side	381.0
Weight of bolts, paint, &c., each side	19.0
Weight of wood backing, 6″, and fastenings, each side	21.0
Weight of plating behind armor, 2″, and connecting angles, each side	52.0
Weight of cellular backing, mantlet, ½″, and connecting angles, each side	54.0
Weight of wing passage complete except floor, each side	20.0
Total weight each side	547.0
Total weight	1,094.0

Armor Bulkhead Forward:

	Tons.
Weight of armor, 15″ (calculated as uniform thickness)	84.75
Weight of bolts, paint, &c	4.25
Weight of wood backing, 6″, and fastenings	3.50
Weight of plating behind armor, 1¾″, and connecting angles	10.00
Weight of cellular backing, mantlet, $\frac{7}{16}$″, and connecting angles	12.50
Total weight	115.00

Armor Bulkhead Aft:

Weight of armor, 14″ (calculated as uniform thickness)	77.00
Weight of bolts, paint, &c	3.75
Weight of wood backing, 6″, and fastenings	3.25
Weight of plating behind armor, 1¾″, and connecting angles	10.00
Weight of cellular backing, mantlet, $\frac{7}{16}$″, and connecting angles	9.00
	103.00

Summary.—Belt and bulkheads.

Belt, including bolts, wood backing, plating behind armor, cellular backing, mantlet, and wing passage	1,094.0
Forward bulkhead including same except wing passage	115.0
After bulkhead including same except wing passage	103.0
Total	1,312.0

REDOUBT, OR TURRET INCLOSURE.

Half circle forward, 16″:	
Weight of armor	187.0
Weight of bolts, paint, &c	15.0
Weight of wood backing, 10″, and fastenings	12.0
Weight of plating behind armor, 2″	21.0
Total 16″ front	235.0
Sides 15″. Mean height, 9.56 feet:	
Weight of armor	225.0
Weight of bolts, paint, &c	18.0
Weight of wood backing, 11″, and fastenings	17.0
Weight of plating behind armor, 2″	0
Total 15″ sides	288.0
After end, 14″. Height, 8 feet:	
Weight of armor	15.0
Weight of bolts, paint, &c	1.25
Weight of wood backing, 12″, and fastenings	1.20
Weight of plating behind armor, 2″	1.75
Total, 14″ after end	19.20
Total weight of redoubt in tons	542.2

NOTE.—In working out the detailed arrangement, the size of this redoubt should be made the least possible to house the gear, as this disposition of armor, though necessary, is not highly efficient.

DECK ARMOR.

	Tons.
3¼″ curved deck, forward of belt; area, 1,152 square feet; weight with fastenings at 134 pounds per square foot	69.0
3¼″ eaves, port and starboard, aft; area, 1,487 square feet; weight with fastenings at 134 pounds per square foot	89.0
2¼″ deck over belt, exclusive of turret and barbette openings; area, 9,275 square feet; weight with fastenings at 113 pounds per square foot	468.0
3″ flat portion, aft; area, 553 square feet; weight with fastenings at 124 pounds per square foot	30.5

	Tons.
Total weight of deck armor with fastenings	656.5
To which add for glacis in various places	10.5
Deck armor and glacis	667.0

TORPEDO OUTFIT.

To consist of 5 under-water tubes, placed one above the protective deck in the center line forward, the muzzle in a boss of the stem with an automatic closing valve; two at 45° with the line of the keel at the forward corners of the belt, worked from the deck next below the armor shelf; and two on the broadside aft just abaft the armor bulkhead and below the protective deck. Ten torpedoes to be carried. The torpedoes to be expelled by steam, compressed air, or gunpowder, as may be desirable.

The weight will be about as follows:

10 torpedoes, at 814 pounds	pounds	8,140
10 dynamite charges at 94.6 pounds	do	946
5 launching tubes and fittings, at 1,800 pounds	do	9,000
Air-compressing machinery, pipes, &c	do	6,000
Spare parts and stores	do	400
		24,486
Tons		10.93

CONNING TOWER, ARMORED HATCH, AND VENTILATING SHAFT.

Conning tower to be 6′ 11″ internal diameter, walls 6′ high and 14″ thick, with 2″ crown and 1½″ base plate. To be located over the ventilating shaft towards its forward edge and entered from beneath. To weigh, complete, about 44 tons.

The ventilating shaft to stand on the back of the redoubt, shaped in plan like anisosceles triangle with rounded corners, the forward corner rounded with a small radius with 12″ of armor within the hatchway to the conning tower, and the telegraphs, voice pipes, &c., to lead below in the forward corner. This hatchway will be completed within by 3″ armor bulkhead separating from air shafts and fixed ammunition hatch. Except in wake of this hatchway the armor to be 9″ thick, flaring at the top to receive the cowls of downtakes. Between the air trunks a hatchway or trunk of light plating on the sides shall supply armored protection for the hand-up of fixed ammunition to the secondary battery, and access from the hurricane deck to the armored portions of the vessel. It must be distinctly understood that enlarging this armored shaft to include the air trunks is only done to give stability both to the shaft as such and as support to the conning tower. Armor gratings to be fitted to the air shafts at the level of the armor, and a 1½″ scuttle over the hatch for general access to the hurricane deck. The whole to weigh not more than 35 tons.

Mast.—A steel mast about 24″ diameter and standing about 54′ above the hurricane deck shall be placed out of the line of fire. To be used for signal purposes, uptake for exhaust ventilation, and to carry a crow's nest with machine gun. A derrick, in connection with the mast, will be fitted for handling the boats.

Anchors and chains.—The vessel to carry two 6-ton Martin anchors on inclined beds with tripping gear. A third spare or sheet may be carried if desired. The chain to be stowed in lockers forward of the armed bulkhead to assist in the protection, and shall be distributed from the side as far as possible athwartships. Steam capstan with double hand barrel shall be fitted. Wrought iron or steel bitts, with portable cowls for ventilation, to be fitted; compressors to be attached to the bitts.

SPEED AND COAL ENDURANCE.

With 7,000 I. H. P. a speed of over 15½ knots should be obtained under measured mile-trial conditions at the load displacement of 7,028 tons. At this speed 300 tons of coal would suffice for 30 hours' steaming, covering a distance of 465 knots. With 600 tons, the distance would be about 900 knots.

With 1,600 I. H. P. a speed of 10 knots should be obtained in smooth water. At this speed 300 tons of coal would suffice for 190 hours' steaming, covering a distance of 1,900 knots. With 600 tons, the distance covered would be about 3,600 knots.

WEIGHT OF HULL.

The hull is to be constructed throughout of mild steel, but of harder quality than at present adopted in the Navy, the outer bottom plating being of steel showing not less than 65,000 pounds tensile strength, with suitable elongation in a standard 8″ piece; inner bottom plating not less than 68,000 pounds; and all angles, tees, and beams, except those exposed to great vibratory strain, or which may require forge work without possibility of annealing, to be of the same quality. In such parts as are in direct compression without possibility of the strain being reversed, as in the immediate supports to the turret, barbette, or redoubt, metal of not less than 70,000 pounds tensile strength in a standard 8″ piece should be used for both plates and stiffeners. Parts requiring to be forged without annealing, to be welded, or to be very heavily wrought, should be of such quality as is at present demanded for the Navy.

All construction, adopted in bulkheads generally for cheapness, which require the corners of plates to be heated and tapered, is to be avoided as far as possible, in order that the desirable quality of steel may be used with perfect safety. For the same reason great care is to be taken to remove the effects of punching.

The quality of the rivet metal and the general size, spacing, and disposition of the rivets, in connection with the harder quality of metal in the parts connected, should be the subject of special attention.

The undoubtedly higher working loads which may be carried in built-up structures riveted by hydraulic machines renders it highly desirable that such appliances be utilized as far as is at all possible.

In general, it is intended that the most improved materials and workmanship shall be used throughout the structure, and that the utmost attention shall be given to the disposition of the materials.

The vessel to have an inner bottom over the length occupied by the belt, with suitable subdivision of the ends (of the vessel) by bulkheads and flats. From the armor-shelf to the turn of the bilge a triple skin will be worked for better protection against torpedo attack. The space between the two inner skins in the midship part may be utilized as portion of the fuel reserve, especially if the manufacture of patent fuel in square bricks convenient for stowage shall have reached a satisfactory stage in this country. Such use will increase its efficiency for torpedo protection.

Throughout the boiler and engine rooms a comparatively heavy middle-line bulkhead, well stiffened, shall extend and be virtually continued well towards the ends of the vessel. Other main subdivisions shall be as close as is consistent with the proper utilization of the space. Along the sides forward, between the protective and berth decks, a coffer-dam of cellular construction, of thickness 3 feet at the protective deck to 4 feet at the berth deck, shall be worked and packed close with cork or cellulose. The water-line aft may be similarly protected if deemed necessary, but no provision has been made for it.

Special attention should be paid to the local support of turret and redoubt by circular and other bulkheads, and to the proper distribution of the stresses. Solid or

GENERAL FEATURES OF A FIRST-CLASS COAST-DEFENSE VESSEL DESIGNED FOR SERVICE IN OPEN BAYS AND DEEP CHANNELS, TO FIGHT IN HEAVY WEATHER, WITH DRAUGHT OF WATER DETERMINED WITH SPECIAL REFERENCE TO SERVICE IN THE CHESAPEAKE BAY.

A vessel has been designed to satisfy the following conditions:

The draught of water not to exceed 19′.

To carry two 14″ B. L. R. guns, in the complete protection of a turret suitably armored and mounted high enough above water to be fought in heavy weather.

Two smaller armor-piercing guns of lighter caliber to be carried with suitable armor protection, and mounted so as to be served with the greatest rapidity. These guns also to command the greatest possible train.

A fairly powerful secondary battery, with suitable shield and bulwark protection and well protected ammunition lead, to be also carried.

A suitable installation of auto-mobile torpedoes expelled under water to be provided, while as complete protection as possible against torpedo attack shall be provided in the hull.

General protection to the hull shall be provided by a water-line belt of 16″ armor, of length about 50 per cent. of the length of the vessel between perpendiculars, terminating in athwartships bulkheads of suitable thickness, and to be continued to the ends of the vessel by underwater decks about 3″ thick, and suitably supported. Deck plating of 2¾″ shall be worked over the belt.

Armor protection for the turret base and loading gear shall be provided by a redoubt or turret-chamber, with about 15″ of armor extending to a suitable height.

In addition, coal shall be carried along the sides above the armor belt.

The vessel should have a maximum speed in smooth water of not less than 15¼ knots under trial conditions with forced draft.

Armored erections should be supported and give support to one another so that as little dependence as possible may be necessary on unarmored supports, and they shall be located so as to interfere as little as possible with the train of the guns and present the smallest possible target.

The coal supply at the load displacement should be sufficient for a somewhat greater distance than 1,500 knots at a speed of 10 knots in fair weather, with bunker capacity for a greater supply.

DESIGN.

The vessel designed to meet these conditions has the following principal dimensions:

Length over all	[illegible] 3″
Length between the perpendiculars	300′ 0″
Beam extreme	[illegible] 0″
Draught, mean and extreme	[illegible] 0″
Displacement	4,500 tons.
Freeboard to top of main deck at side over bow	[illegible] 4″
Freeboard to top of main deck aft	5′ 9″
Armored freeboard in waist of bow	2′ [illegible]″
Moulded depth from flat keel to top of main-deck beam amidships	[illegible] [illegible]″

Form.—The ratio of beam to length is 1 : 4.[illegible], and the coefficient of fineness on the principal dimensions, 0.6131. The area of midship section is 1,088.5 square feet, and the coefficient of fineness on the midship section, 0.6742. The center buoyancy is 1′ 9¾″ abaft the middle of the length, and 8′ 2½″ below the load water-line. The transverse metacenter above the center of buoyancy is 15′ 10½″, and above the water-line, 7′ 8″. The tons per inch of immersion at the load-draught is 35.67.

PROPELLING MACHINERY.

To develop 4,650 I. H. P. with open stokeholds, and not less than 6,500 I. H. P. with stokeholds under pressure, or by other approved system of forcing the draft, when burning Sixon's navigation coal, or its equivalent, under standard conditions of smooth-water trial.

Boilers.—Sufficient boiler-power to be provided for auxiliary and main engines, besides which a donkey boiler with about 25 square feet of grate shall be carried, if possible in the deck erection, capable of making steam for ordinary ventilation and lighting purposes, anchor-hoisting and derrick engines, and at least one powerful steam-pump, and arranged to heat up the main boilers in raising steam or getting under way. Apparatus to be attached to this donkey boiler for forcing its combustion immediately whenever necessary.

The main boilers to be eight in number, of cylindrical single-ended type, 13′ 6″ diameter, 9′ 9″ long, each with three furnaces about 40″ internal diameter; grate about 6′ 3″ long, and having an aggregate grate surface of not less than 500 square feet. To supply steam of 110 pounds pressure. To be placed in pairs in four separate compartments, two on each side of the middle-line bulkhead, the boilers back to back at the middle line, stokeholds fore-and-aft outboard, with complete facilities for ready supply of coal to the fires. The four boilers in the two compartments on each side to be served by the same stack, the uptakes joining above the deck-plating, the openings in which are to be made good by armor-gratings and coffer-dams.

The weight of boilers, including donkey, with water and all attachments, and boiler-room fittings, not to exceed 395 tons.

Engines.—To be of three-cylinder vertical inverted compound type driving twin screws. Cylinders about 40″ and 56″ diameter and 36″ stroke. The engine driving each screw to be in a separate compartment formed by the middle-line bulkhead. The greatest care should be taken to obtain the necessary rigidity of the bearers with the minimum of material.

To have independent circulating pumps, fitted so that they may be used to remove water from the ship.

To weigh, with water in condensers and all attachments, including stores and spare parts, not more than 260 tons.

Screws.—To be of steel or suitable composition, four bladed, about 14′ 6″ diameter, and of suitable pitch.

Shafting.—Hollow shafts of Whitworth or equivalent steel should be used.

The weight of shafting, plummer blocks, stern tubes, screws and struts, and miscellaneous, not to exceed 65 tons.

Total weight.—Total weight of propelling machinery, as above, not to exceed 720 tons.

MAIN BATTERY.

Turret.—To mount two 14″ 75-ton B. L. R. on port pivoted slides. As shown in the drawing, the guns are mounted to load in only one position. If, however, a satisfactory arrangement can be perfected for loading in any position of turret without adding to the weight of the ship, it may be adopted instead.

Thickness of steel armor	16″
Thickness of wood backing	6″
Thickness of plating behind armor	1½″
Depth of cellular structure	16″
Thickness of mantlet	$\frac{7}{16}$″
External diameter	32′ 2″
Internal diameter	25′ 6″
Height of lower edge of port above L. W. L.	13′ 8″
Thickness of crown	2″

A ventilating hatch with armored grating will be fitted in the center of the crown, and an updraft shall be maintained in the turret to clear it of any smoke which may enter when the breech is opened.

Guns and loading gear.—The following particulars will be sufficient for proposed high-power 14″ B. L. R.:

Length	inches	475
Weight of charge	pounds	700
Weight of projectile	dó	1,400
Weight of gun	tons	75

The guns load in a fixed position of turret. A telescopic rammer to be used reaching to the half seating of the projectile. The guns load run in and elevated.

Approximate weight of turrets, guns, and gear.

	Tons.
Guns 2 by 75	150.0
Gun-slides with recoil presses, &c	40.0
Gun-carriages, straps over guns, &c	14.0
Armor (16″)	218.0
Bolts	15.0
Crown (2″) grating, hoods, &c	30.0
Wood backing (6″) and fastenings	9.0
Plating behind armor (1½″) and connecting angles	21.5
Cellular backing and mantlet	16.0
Platform, armor-shelf and framing below it, beams to crown, rollers and roller bases, racks, apron, locking-bolts, &c., lifting presses, and all gear connected directly to the turret proper	80.0
Total weight of turret and guns with gear	593.5

Ammunition for 14″ guns.

Weight of 1 round with cases	pounds..	2,300
Weight of 90 rounds with cases	tons..	92.5
Weight of gun and magazine equipment	do...	3.5
Total weight of turret, guns, mountings, and ammunition	do...	690

Barbette.—To mount two 10″ B. L. R. guns. The floor of the barbette to be recessed below the deck and protected by a 2″ base-plate. Protection from above to be afforded by a 2″ screen, carried partly on the turntable and part secured to the fixed portion of the barbette.

An armored ammunition tube, 6′ 9″ internal diameter and 7″ thick, will afford a protected lead for the power, ammunition, and access. Besides the support afforded by this tube and the ordinary ship's framing, special support will be supplied by numerous stanchions or circular bulkheads.

Thickness of steel armor, front and sides	11″
Thickness of steel armor, rear	9″
Thickness of wood backing	10″
Thickness of plating behind armor	1″
Bolt-head sockets set up above inner surface	2″
Thickness of armored wall	22″
Height of top of armor above main deck	7′ 0″
Height of center of guns (horizontal) above L. W. L	18′ 9″
Internal diameter of round of barbette	17′ 6″
External diameter of round of barbette	21′ 2″
Length of barbette over all	28′ 8″

Guns and loading gear.—The guns are of the Bureau of Ordnance design, with particulars as elsewhere mentioned.

To be mounted on slides pivoted as far out as possible, so that the guns may be exposed as little as possible. The guns to load run in and elevated to about 13° at a fixed train; to be served by protected ammunition hoist and hydraulic loading-gear in rear of the turntable.

Distance from center to center of gun	56″
Maximum elevation	15°
Maximum depression	7°

Approximate weight of barbette, guns, and gear.

	Tons.
Guns 2 by 26	52.0
Gun-slides with recoil presses, &c	19.0
Gun-carriages, straps over guns, &c	8.0
Turntable, including lifting presses, turning engines, rollers, &c	30.0
Loading gear and ammunition hoists	4.0
Armor (11″ front and sides and 9″ rear)	100.0
Bolts, paint, &c	9.0
Wood backing and fastenings	10.0
Framing of sides and floor, plating behind armor, &c	18.0
Base plate and overhead screen (2″)	30.0
Ammunition tube and its connections	19.0
Total weight of barbette, guns, and gear	299.0

Ammunition for 10″ guns.

Weight of 1 round with cases	pounds..	865.0
Weight of 140 rounds with cases	tons..	54.0
Weight of gun and magazine equipment	do...	1.5

General summary.

MAIN BATTERY.

	Tons.
Turret, two 14″ guns and gear	594.0
Ammunition for 14″ guns	92.5
Gun and magazine equipment for 14″ guns	3.5
Barbette, two 10″ guns with gear	300.0
Ammunition for 10″ guns	54.0
Gun and magazine equipment for 10″ guns	1.5
Total weight main battery	1,055.5

SECONDARY BATTERY.

Four 57mm single-shot rapid-firing cannon:

	Pounds.
Guns and mountings, 4 by 2,200	8,800
Ammunition in cases (960 rounds, 70 cases, each)	49,000
Shields, heavy, 4 by 1,500	6,000
	63,800

Three 47mm revolver Hotchkiss:

Guns and mounting (one in crow's nest)	7,000
Ammunition in cases (1,920 rounds, 80 cases, each)	24,000
Shields, 3 by 1,000	3,000
	34,000

Four short Gatlings:

Guns and mountings, rail, 4 by 400	1,600
Ammunition in cases (4,000 rounds each)	1,760
Shields, 4 by 500	2,000
	5,360

Summary.—Secondary battery.

Four 57mm 6-pounder, rapid firing, ammunition and shields	63,800
Three 47mm revolvers	34,000
Four short Gatlings	5,360
Equipment, stores and spare parts, search-lights, &c.	3,000
Total	106,160
	or 47.4 tons.

VERTICAL ARMOR.

Side armor, as per section and plans:

Length of belt	160′ 0
	Tons.
Weight of side armor, 16″ each side	280.66
Weight of bolts, paint, &c., each side	14.03
Weight of wood backing, 6″, and fastenings, each side	16.30
Weight of plating behind armor (2″) and connecting angles, each side	43.54
Weight of cellular backing and mantlet, $\frac{7}{16}$″, each side	40.00
Weight of wing passage complete, except floor, each side	14.80
Total weight, each side	409.33
Total weight, both sides	818.66

Armor bulkhead—forward:

Weight of armor, 15″	91.60
Weight of bolts, paint, &c	4.58
Weight of wood backing, 6″	3.60
Weight of plating behind armor, 1½″, and connecting angles	11.22
Weight of cellular backing, mantlet, $\frac{7}{16}$″	11.00
Total weight	122.00

Armor bulkhead—aft:	
Weight of armor, 14″	69.70
Weight of bolts, paint, &c	3.50
Weight of wood backing, 6″	3.20
Weight of plating behind armor, 1¼″, and connecting angles	10.30
Weight of cellular backing, mantlet, $\frac{7}{16}$″	10.10
Total weight	96.80

Summary.—Belt and bulkheads.

Belt, including bolts, wood backing, plating behind armor, cellular backing, mantlet, and wing passage	818.66
Forward bulkhead, including same, except wing passage	122.00
After bulkhead, including same, excepting wing passage	96.80
Total	1,037.46

REDOUBT, OR TURRET INCLOSURE.

Half-circle forward, 15″:	
Weight of armor	157.2
Weight of bolts, paint, &c	12.6
Weight of wood backing, 10″, and fastenings	11.0
Weight of plating behind armor, 2″	19.2
Total, 15″ front	200.0
Sides, 14″. Mean height, 9.80′:	
Weight of armor	190.0
Weight of bolts, paint, &c	15.2
Weight of wood backing, 11″, and fastenings	16.0
Weight of plating behind armor, 2″	25.8
Total, 14″ sides	247.0
After-end, 14″. Height, 8′:	
Weight of armor	15.3
Weight of bolts, paint, &c	1.25
Weight of wood backing, 11″, and fastenings	1.00
Weight of plating behind armor, 2″	1.75
Total, 14″, after-end	19.30
Total weight of redoubt, in tons	466.3

DECK ARMOR.

3″ curved deck forward of belt; area, 2,548 square feet. Weight, with fastenings, at 124 pounds per square foot	141.0
2¾″ deck over belt, exclusive of turret opening; area, 8,820 square feet. Weight, with fastenings, at 113 pounds	445.0
3″ eaves, port and starboard, aft; area, 1,502 square feet. Weight, with fastenings, at 124 pounds	83.0
2¾″ flat portion aft; area, 646 square feet. Weight, with fastenings, at 113 pounds	32.6
Total weight of deck armor, with fastenings	701.6
To which add for glacis in various places	10.4
Deck armor and glacis	712.0

TORPEDO OUTFIT.

To consist of 5 under-water tubes, placed one above the protective deck in the center line forward, the muzzle in a boss of the stem, with an automatic closing valve; two at 45° with the line of the keel, at the forward corners of the belt, worked from the deck next below the armor shelf; and two on the broadside aft, just abaft the armor bulkhead and below the protective deck.

Ten torpedoes to be carried. The torpedoes to be expelled by steam, compressed air, or gun powder, as may be desirable.

The weight will be about as follows:

	Pounds.
10 torpedoes, at 814 pounds	8,140
10 dynamite charges, at 94.6 pounds	946
5 launching tubes and fittings, at 1,800 pounds	9,000
Air-compressing machinery, pipes, &c	6,000
Spare parts and stores	400
Total	24,486
	or 10.93 tons.

If hereafter considered desirable, above-water torpedo tubes can be fitted working through the side coal-bunkers, but little confidence can be placed in them under the conditions of hard fighting for which the vessel is designed.

CONNING TOWER AND ARMORED HATCH.

Conning tower to be 6′ 11″ internal diameter, walls 6′ high and 14″ thick, with 2″ crown and 1½″ base plate; to be supported by the armored hatch, through which it is entered from beneath; to weigh, complete, about 44 tons.

The armored hatch to stand on the back of the redoubt, shaped as shown in the plans, the forward corner rounded to a small radius with 12″ of armor within the hatchway leading to the conning tower, and the telegraphs, voice-pipes, &c., to lead below in this corner. The hatchway to the conning tower will be separated from the remainder of the trunk by a 3″ bulkhead, beyond which the armor will be 9″ thick.

A 1½″ hinged scuttle will be fitted over the hatch for general access to the hurricane-deck outside the conning tower; the whole to weigh not more than 26 tons.

Mast.—A steel mast about 24″ in diameter and standing about 54′ above the hurricane-deck shall be placed out of the line of fire; to be used for signal purposes, uptake for exhaust ventilation, and to carry a crow's nest with machine gun. A derrick, in connection with the mast, will be fitted for handling the boats.

Anchors and chains.—The vessel to carry two 5½-ton Martin anchors on inclined beds with tripping gear. A third spare or sheet may be carried if desired. The chain to be stowed in lockers forward of the armored bulkhead to assist in the protection, and shall be distributed from the side as far as possible athwartships. Steam capstan with double hand-barrel shall be fitted. Wrought iron or steel bitts, with portable cowls for ventilation, to be fitted; compressors to be attached to the bitts.

SPEED AND COAL ENDURANCE.

With 6,500 I. H. P. a speed of over 15¼ knots should be obtained under measured mile-trial conditions at the load displacement of 6,500 tons. At this speed 270 tons of coal would suffice for 28½ hours' steaming, covering a distance of 435 knots. With 550 tons, the distance would be about 880 knots.

With 1,500 I. H. P. a speed of 10 knots should be obtained in smooth water. At this speed 270 tons of coal would suffice for 175 hours' steaming, covering a distance of 1,750 knots. With 550 tons, the distance covered would be about 3,500 knots.

WEIGHT OF HULL.

The vessel to be constructed under the same conditions as to quality and disposition of materials and of workmanship as specified for the 7,000-ton vessel.

The weight of hull and fittings, exclusive of deck erection, plating behind armor, and wing passage, should not exceed 1,810 tons.

General summary of weights.

	Tons.
Hull and fittings, exclusive of deck erection, plating behind armor, and wing passage	1,810
Deck erection	40
Cork packing and subdivision forward	20
Belt and bulkheads, including wood backing, plating behind armor, cellular backing and bolts, wing passage, paint, &c	1,038
Redoubt, or turret inclosure	470
Deck armor and glacis	712
Turret, two, 14-inch guns, gear, and ammunition	690
Barbette, two, 10-inch guns, gear, and ammunition	355.5
Secondary battery with ammunition and shields	47.5
Conning tower and armored shaft	70
Torpedo outfit	11
Auxiliary machinery	75
Propelling machinery with water in boilers and condensers, all attachments and stores	720
Coal at load displacement	270
Anchors and chains	65
Water and tanks	23
Provisions and all stores	40
Complement, 310, and effects	32
Boats	10
Total weight or displacement	6,499

COST.

The estimated cost of hull and machinery, exclusive of armament, its immediate fittings and ammunition, is $2,950,000.

With armament complete, ammunition, torpedoes, and torpedo apparatus, and the vessel complete and ready for sea in all respects, the estimated cost is $3,575,000.

GENERAL FEATURES OF A SECOND-CLASS COAST-DEFENSE VESSEL, DESIGNED FOR GENERAL SERVICE ON THE COASTS OF THE UNITED STATES, OR FOR OFFENSIVE OPERATIONS IN NEIGHBORING WATERS.

The vessel has been designed to satisfy the following conditions:

Besides possessing a high general efficiency, the vessel is to be suited for both the outer and inner lines of harbor defense, to which end the heaviest fire and protection shall be forward; a powerful ram bow shall be fitted; the decks protected as well as may be from plunging fire; maneuvering power highly developed; a fairly powerful installation of automobile torpedoes expelled under water from positions favorable to attack to be provided, while as much protection from similar attack is given as is possible in the hull; as powerful a secondary battery to be fitted as may be fought under reasonable cover, with special regard to protected ammunition supply. The heavy battery shall be so mounted as to obtain the greatest range and accuracy of fire possible, and the forward guns should be fully protected.

The vessel should have a maximum speed in smooth water of not less than 13 knots, as it is deemed that vessels of greater deep-water speed will not utilize it fully under the conditions of warfare over the shoals and bars in contracted harbors and their approaches. Her draught should be the least consistent with housing screws of size suitable for the necessary motive power.

It may be laid down that for a vessel designed to fight on occasions at close quarters thin vertical armor is worse than useless, and in no case should the thickness be less than half the caliber of her heavy guns; accordingly the vertical armor should be confined to such dimensions as will permit a sufficiency of buoyancy and stability to be retained after the maximum amount of injury possible in the unarmored portions has been done, and its thickness to be the maximum possible. Outside the belt the buoyancy should be protected by thick deck plating, presenting a small inclination to the horizontal in the neighborhood of the water line, and the water line should be further supported by a cork or cellulose belt, at least forward.

The armored erections, such as ventilating shaft, conning tower, and stack, shall be designed to be as light as possible consistent with the requisite protection, and shall give support to one another and to the bridge. They shall also be located so as to interfere as little as possible with the train of the guns, and present the smallest possible target.

The coal supply at the load displacement should be sufficient for a distance of 1,000 miles at 10 knots in fair weather, with bunker capacity for a greater supply.

DESIGN.

A vessel has been designed to meet these conditions, of which the following is a general description:

Principal dimensions.

Length between perpendiculars	260′ 0″
Beam, extreme	57′ 6″
Mean draught	14′ 6″
Displacement	4,018 tons.
Freeboard at side to top of deck plating	3′ 0″
Molded depth from flat keel to top of beam amidships	18′ 3″

Form.—The bow is as sharp as possible consistent with sufficient support to the ram, and the run easy for efficiency of screws and rudder. The coefficient of fineness on the extreme dimensions is 0.6488, the area of midship section 782.6 square feet, and the coefficient of fineness on the midship section 0.69.12 The center of buoyancy is $3\frac{7}{8}$″ forward of the middle of the length and 6′ 2″ below the water line. The transverse metacenter above the center of buoyancy is 17′ $6\frac{7}{8}$″ and above the water line 11′ $4\frac{7}{8}$″. The tons per inch of immersion at the load draught is 27.63.

Propelling machinery.—To develop 2,500 I. H. P. at slow speed of fans and a maximum of over 3,300 I. H. P. when burning selected bituminous coal under standard conditions of smooth-water trial.

Boilers.—Sufficient boiler power to be provided for both auxiliary and main engines, and besides a donkey boiler, with about 40 square feet of grate, placed in an ordinarily well ventilated location, capable of making steam for ordinary ventilating and lighting purposes, and for working at least one powerful steam-pump.

The main boilers to be six in number, of cylindrical single-ended type 12′ 6″ in diameter, 9′ 9″ long, each with three furnaces 39″ internal diameter, grates 6′ 6″ long, and having an aggregate grate surface of 375 square feet. To supply steam of 100 pounds pressure.

The weight of boilers, including donkey, with water and all attachments and boiler-room fittings, not to exceed 230 tons. Double-ended boilers may be used if found practicable.

Engines.—The main engines turning the screws to develop 2,500 I. H. P. under ordinary circumstances, and to be capable of a maximum of 3,500 I. H. P. under forced conditions. To be of two-cylinder direct-acting compound type driving twin screws. Cylinders about 30″ and 57″ diameter and 36″ stroke. To have independent air and circulating pumps, and both air and circulating pumps arranged so that they may be used to remove water from the ship. To weigh, with water in condensers and all attachments, including stores and spare parts, not more than 155 tons.

Screws.—To be three-bladed, of steel or suitable composition, about 11′ 6″ diameter, and of suitable pitch.

Shafting.—Hollow shafts of Whitworth or equivalent steel should be used.

The weight of shafting, plummer blocks, stern tubes, screws and struts, and miscellaneous not to exceed 40 tons.

Total weight of propelling machinery not to exceed 425 tons.

MAIN BATTERY.

Turret.—The turret forward should have an internal diameter of about 21 feet, with a crown of 2″ plating. An armored grating in the center of the crown to be fitted for ventilation.

Thickness of steel armor:		
Port plates	inches..	16
Rear plates	do...	14
Thickness of wood backing:		
To port plates	do...	8
To rear plates	do...	10
Plating behind armor, two ¾″ thicknesses	do...	1½
Girders behind plating, deep	do...	10
Mantlet or inner shell	do...	½
Total thickness of wall	do...	36
Internal diameter	feet..	21
External diameter	do...	27
To be designed for extreme elevation of	degrees..	8
And extreme depression of	do...	2

Guns and loading gear.—The guns, 12″ B. L. R., are of the Bureau of Ordnance design, with the following general particulars:

Length	inches..	421.84
Weight of guns	tons..	44
Weight of charge	pounds..	425
Weight of shell	do...	850
Estimated muzzle velocity	foot-seconds..	2,000
Estimated muzzle energy	foot-tons..	23,500
Approximate penetration at muzzle in inches of wrought iron	inches..	26

The guns to be mounted on port pivoted carriages. Ammunition-hoist in center of turret, with combination trolly carrying two half-charges and projectile. Telescope rammer reaching to half-seating of projectile, worked entirely within the turret, so that the guns load in any position of turret. Guns run out to load.

Approximate weight of turret, guns, and gear.

	Tons.
Guns, 2 by 44	88.0
Gun-slides, with recoil presses, &c	23.0
Gun-carriages, straps over guns, &c	8.5
Turret, including lifting presses, &c., rollers and roller bases, racks, apron, locking bolts, &c	325.0
Total weight of turret and guns with gear	444.5

Ammunition for 12″ guns.

Weight of one round with cases	pounds..	1,400
Weight of 120 rounds with cases	tons..	75.0
Gun and magazine equipment	do...	2.0

Barbette.—To mount two 10″ B. L. R. guns *en barbette* so as to load at any train will require a barbette 19′ 6″ internal diameter.

Thickness of steel armor	11½″
Thickness of plating behind armor 2–½″	1″
Thickness of wood backing	10″
Bolt-head castings set up above inner surface	4″
Thickness of armored wall	22½″
Height of top of armor above deck	7′ 0″
Internal diameter of barbette, inner surface of plating behind armor	19′ 9″
External diameter of barbette	23′ 6″
Distance from center to center of guns	74″
Height of center of gun, horizontal, above deck	104″

Guns and loading gear.—The guns, 10″ B. L. R., are of the Bureau of Ordnance design, with the following general particulars:

Length	inches	329.1
Weight of gun	tons	26
Weight of charge	pounds	250
Weight of shell	do	560
Estimated muzzle velocity	foot-seconds	2,050
Estimated muzzle energy	foot-tons	14,600
Approximate penetration at muzzle in inches of wrought iron		22.5

The guns to be mounted on a turn-table and pivoted as far out as possible. To be served by ammunition-hoist in the center with combination trolly. Telescopic rammer reaching to half-seating of projectile worked entirely from the turn-table, so that the guns load in any position. Guns run out and elevate to load.

Approximate weight of barbette, guns, and gear.

	Tons.
Guns, 2 by 26	52.0
Gun-slides, with recoil presses, &c	20.0
Gun-carriages, straps over guns, &c	8.0
Turn-table, including lifting presses, rammers, and loading gear, rollers, 2″ screen, &c.	45.0
Armor, 11½″	105.0
Bolts	9.0
Backing, fastenings, and paint	14.0
Framing and plating behind armor, roller bases, rack, &c	20.0
Total weight of barbette, guns, and gear	273.0

Ammunition for 10″ guns.

Weight of one round, with cases	pounds	865
Weight of 140 rounds, with cases	tons	54.0
Weight of gun and magazine equipment	do	1.5

General summary.

MAIN BATTERY.

	Tons.
Turret, two 12″ guns and gear	444.5
Ammunition for 12″ guns	75.0
Gun and magazine equipment for 12″ guns	2.0
Barbette, two 10″ guns, with gear	273.0
Ammunition for 10″ guns	54.0
Gun and magazine equipment for 10″ guns	1.5
Total weight main battery	850.0

SECONDARY BATTERY.

	Pounds.
Two 57mm single-shot, rapid-firing Hotchkiss cannon:	
Guns and mounting, 2 by 2,200	4,400
Ammunition in cases, 1,120 rounds each, 80 cases	27,900
Shields, heavy, 2 by 1,500	3,000
	35,300
Two 47mm revolver Hotchkiss:	
Guns and mounting, one in crow's nest	4,600
Ammunition in cases, 2,160 rounds each, 90 cases	17,910
Shields, 2 by 1,000	2,000
	24,510
Three short Gatlings:	
Guns and mounting, rail, 3 by 400	1,200
Ammunition in cases, 4,000 rounds each	1,314
Shields, 500 by 3	1,500
	4,014

Summary.

Two 57mm 6-pounder, rapid-fire, ammunition and shields	35,300
Two 47mm revolvers, ammunition and shields	24,510
Three light Gatlings	4,014
Equipment, stores, search-lights, &c	2,000
	65,824
	or 29.4 tons.

VERTICAL ARMOR.

Side armor, as per midship section and plans:	
Length of belt on side	131′ 7″
Length of belt from end to end of bulkheads	155′ 2″
	Tons.
Weight of side armor, 12″, each side	183.25
Weight of bolts, paint, &c., each side	9.20
Weight of wood backing, 6″, teak and fastenings, each side	13.00
Weight of plating behind armor, 1½″, each side	26.00
Weight of cellular backing, plates, and angles, 7-16″, each side	20.50
Weight of mantlet, 7-16″, each side	8.40
Weight of wing passage, plates, and angles, 7-16″, each side	13.20
Total weight on one side	273.55
Total weight on both sides	547.00
Armor bulkhead—forward:	
Weight of armor, 13″	57.40
Weight of bolts, paints, &c	2.90
Weight of wood backing, 6″, teak and fastenings	2.44
Weight of plating behind armor, 1½″	5.70
Weight of cellular backing, plates, and angles, 7-16″	3.94
Weight of mantlet, ½″	1.90
Total weight forward bulkhead	74.28
Armor bulkhead—aft:	
Weight of armor, 10″	48.50
Weight of bolts, paint, &c	2.50
Weight of wood backing, 6″, teak and fastenings	3.00
Weight of plating behind armor, 1″	4.88
Weight of cellular structure and mantlet where worked	6.70
Total weight, after bulkhead	65.58

Summary.

	Tons.
Side armor, including bolts, wood backing, plating behind armor, cellular backing, mantlet, and wing passage	547.00
Forward bulkhead, including same, except wing passage	74.28
After bulkhead, including same, except wing passage	65.58
Total weight of vertical armor, including as above	687.00

DECK ARMOR.

4″ curved deck forward of belt; area, 1594.5 square feet; weight, with fastenings, at 164 pounds per square foot	tons	116.75
2½″ deck over belt, exclusive of turret and barbette openings; area, 6998.32 square feet; weight, with fastenings, at 103 pounds per square foot	tons	321.80
2½″ curved deck abaft belt; area, 1623.54 square feet; weight, with fastenings, at 113 pounds per square foot	tons	81.90
Total weight of deck armor, with fastenings	do	520.45

The glacis around barbette and turrets may not weigh more than 20 tons.

TORPEDO OUTFIT.

The torpedo outfit is to consist of three under-water tubes, placed, one above the protective deck in the center line forward, fixed in position, and the muzzle in a boss of the stem, with an automatic valve closing it; the other two fixed at a desirable angle with the line of keel below the deck, forward, one on each side. Six torpedoes to be carried. The torpedoes may be expelled by steam or compressed air, as may be advisable. The weight will be about as follows:

	Pounds.
6 torpedoes, at 814 pounds	4,884
6 dynamite charges, at 94.6	568
3 launching tubes and fittings, at 1,800 pounds	5,400
Air-compressing machinery, pipes, &c	4,000
Spare parts and stores	200
Total outfit	15,052
or tons,	6.75

SPEED AND COAL ENDURANCE.

With 3,500 I. H. P. a speed of over 13 knots should be obtained under trial conditions. At this speed 200 tons of coal would suffice for 39 hours' steaming, covering a distance of 510 knots. With 330 tons the distance at 13 knots should be about 830 knots.

With 1,400 I. H. P. a speed of 10 knots should be obtained, and with the increased economy of coal, 200 tons should suffice for 130 hours' steaming, covering a distance of 1,300 knots. With 330 tons the distance at 10 knots should be about 2,000 knots.

CONNING TOWER, VENTILATING SHAFT, STACK, AND BRIDGES.

Conning tower to be 6′ 6″ internal diameter, walls 6′ high and 12″ thick, with 2″ crown and 1″ base plate. To be located over the ventilating shaft, towards its forward edge, and entered from beneath, and from the rear if hereafter deemed advisable. To weigh complete about 36 tons.

Ventilating shaft to stand 8′ high above the deck, shaped in plan like an isosceles triangle, with rounded corners, the forward corner rounded to a small radius, with 9″ of armor within the tube for access to conning tower and lead of tubes, &c. The after corners to be flared out to receive the cowls of ventilating down-takes. The tube for access to conning tower to be completed by a semi-hexagonal 3″ plate; and abaft shall extend, within the protection of the ventilating shaft, a trunk or shaft for access to bridge and for lead of fixed ammunition to secondary battery. With the exception of the tube before mentioned, the thickness of armor to be 6″. The air trunk to be continued by light plating above the top of conning tower and finished with large cowls. Armored gratings to be fitted in the air shafts at the level of the armor, and 1½″ scuttle fitted over the hatch for access to bridge. The whole to weigh not more than 21 tons.

The stack to stand 8′ above the deck; internal diameter, 8′ 6″; to be 4″ thick, with armor grating worked at the level of the deck. To weigh complete about 16½ tons.

A light bridge, with bulwark 36″ high, in wake of the mounting of the secondary battery, and elsewhere with a light rail, to extend from the ventilating shaft to the upper deck aft. To weigh not more than 8 tons.

Mast.—A steel mast about 20″ diameter and about 51′ high above the deck shall be placed abaft the smoke-stack out of the line of fire, for signal purposes, and fitted as an up-take for exhaust ventilation. A crow's nest, with platform about 42′ above the deck, shall be built near the top, mounting a 47^{mm} revolver with complete all-round fire.

Anchors and chain.—The vessel to carry two heavy Martin anchors, on inclined beds, with tripping gear. The chain-lockers shall extend through the protective deck forward to such a depth that when the chain is stowed it shall stand partly above the protective plating, and shall be distributed as far as possible athwartships. The anchor-hoisting engine and windlass shall also be located above the protective deck, care being taken that the lead of pipes, &c., may penetrate the protective plating as little as possible. Access to be had to this space through the same hatch as gives access to the torpedo compartment.

WEIGHT OF HULL.

The hull is to be constructed throughout of mild steel, the outer plating being of about the quality now adopted for naval ship-building; elsewhere, except in forged and welded work, harder steel to be used, with from 10 to 20 per cent. higher tensile strength.

The vessel to have a complete inner bottom, except at the extremities, where close subdivision by bulkheads and flats will serve the same end. From the armor shelf to the turn of the bilge a triple skin will be worked, with close subdivision, for better protection against torpedo attack. The space between the two inner skins in the midship part may be utilized as a fuel reserve, especially if the manufacture of artificial or patent fuel in square bricks convenient for stowage shall have reached a satisfactory stage in this country. Such use will increase its efficiency for torpedo protection.

The main subdivision of the hull by transverse and longitudinal bulkheads shall be as close as the utilization of the space will permit, and especially so forward and along the sides. The space above the protective deck forward will be also well subdivided, and along the side, for a thickness of 4′, cellular coffer-dams will be worked and packed tight with cork or cellulose, while the midship spaces will be used as far as possible for warrant and other light and bulky stores. The water-line aft may be similarly protected.

Heavy fittings will be avoided as far as possible, and no machinery will be used except such as is absolutely necessary.

The ventilation and drainage should be complete and thorough.

Attention must be paid in detailed design to the special strengthening required under the concentrated weights of turret and barbette.

The scantlings of the hull should be as light as possible consistent with strength, as in such a vessel great care must be taken of the hull to prevent corrosion.

The weight of hull as given in the following general summary of weights is obtained by comparison from several low free-board iron war ships. The plating behind armor and wing passage, usually included under this head, has in this case been included in vertical armor. It is believed to be sufficient with careful design and disposition of material in accordance with recent practice:

General summary of weights.

	Tons.
Hull and fittings, exclusive of deck erection, bridge, plating behind armor, and wing passage	970
Deck erection	35
Cork packing along the sides forward over protective deck	20
Screws and shafting, stern tubes, &c	40
Engines and engineer's stores complete, with water in condensers	155
Boilers complete, with water	230
Barbette, 10″ guns and gear	273
Ammunition for 10″ guns, 70 rounds each	55.5
Vertical armor	690
Deck armor	520
Glacis to turret and barbette	20
Turret, 12″ guns, and gear	445
Conning tower, ventilating shaft, stack, and bridge	82
Ammunition for 12″ guns, 60 rounds each	77.5
Secondary battery with ammunition and shields	29.5
Torpedo outfit	6.8
Auxiliary machinery	55
Coal at load displacement	200
Anchors and chains	40
Water and tanks	10
Provisions and all stores	30
Boats	7
Complement, 200, and effects	25
	4,016.3

The estimated cost of hull and machinery, exclusive of armament and its immediate fittings and ammunition, is $1,750,000.

With armament complete, ammunition, torpedoes, and torpedo apparatus, and the vessel complete and ready for sea in all respects, the estimated cost is $2,200,000.

GENERAL FEATURES OF A LIGHT-DRAUGHT HARBOR-DEFENSE GUNBOAT, DESIGNED FOR SERVICE IN SHALLOW BAYS AND NARROW CHANNELS, TO CARRY A SINGLE ARMOR-PIERCING GUN, WHICH MAY BE FOUGHT IN SUCH WATERS IN MODERATE WEATHER.

A vessel has been designed to satisfy the following conditions:

The draught of water not to exceed 7′ when deep loaded.

To be very handy and especially designed for bow attack.

To carry one medium power 10″ B. L. R. mounted forward on the line of keel on a port-pivoted slide carried by two bulkheads thoroughly worked into the hull of the vessel. Also four 57^{mm} rapid-fire Hotchkiss cannon mounted at points of vantage, and with direct ahead fire, and one 37^{mm} revolver in a crow's nest on a military mast.

The water line in wake of boilers, engines, and magazines to be partially protected from machine-gun fire by a thick strake above the water-tight deck, the thick strake terminating forward in a thick bulkhead inclosing the gun-pit. Besides which the coal is to be so distributed as to obtain the maximum protection from it, both above and below the water line. The gun and gunners to be protected from ahead by a fixed curved shield about 2″ thick. The side plating above the coal-bunkers to be thickened in wake of the rapid-fire gun-ports. A water-tight steel deck to be worked below the water line with sloping sides outboard from the stem to the forward engine-room bulkhead, beyond which the side slopes will be continued to the after engine-room bulkhead.

To have twin screws, large rudder area, and steering gear protected as far as possible.

To have a maximum smooth-water speed of not less than ten knots under standard conditions of measured mile trial with forced draft.

To carry coal enough at the load displacement for 1,000 miles, steaming at 8 knots, with bunker capacity for a larger supply.

DESIGN.

The vessel designed to meet these conditions has the following principal dimensions:

Length over all	109′ 3″
Length between perpendiculars	105′ 0″
Beam extreme	27′ 6″
Draught, mean and extreme	6′ 6″
Displacement	300 tons.

Form.—The ratio of beam to length is 1:3.8182, and the coefficient of fineness on the extreme dimensions, 0.5597. The area of midship section is 154.5 square feet, and

the coefficient of fineness on the midship section 0.6476. The center of buoyancy is 0.525 feet forward of the middle of the length and 2.673 feet below the water line. Transverse metacenter above the water line is 6.98 feet. The tons per inch of immersion at the load draught is 5.212 tons.

PROPELLING MACHINERY.

To develop 350 I. H. P. with closed stokeholds and an air pressure of about 2½ inches of water when burning the best coal under standard conditions of smooth-water trial.

Boilers.—The boilers are two in number, of the locomotive type, placed one on each side of the vessel in separate air-tight compartments, each served by its own stack, and a fan to be placed in each fire-room worked by a shaft led through a casing from the fan-engines in the forward engine-room. Each engine is to be commonly worked from its own boiler, but the lead of steam and feed pipes will be such that both engines may be driven from a single boiler when required.

Each boiler to be 3′ 3″ diameter of barrel, 9′ long over the smoke-box; the grate to be 2′ 10″ by 3′ 3″, grate surface 9.2 square feet; length of tubes, 4′ 5″; diameter, 1½″; to supply steam of 130 pounds; to be constructed throughout of steel of suitable quality. A feed-tank containing 300 pounds of fresh water to be fitted in each engine-room, as the boilers are to be worked with fresh water only.

As the uptakes of the boilers are led near the corners of the magazine, special means must be adopted to obviate the effect on the temperature of the magazine. The corresponding corners of the magazine shall be used for handing room, and the lining of these parts will be of a special character.

Spring hatch-covers will be fitted to the fire-rooms for ready egress in emergencies.

The weight of each boiler with water and all attachments and boiler-room fittings may not exceed 10,000 pounds.

Engines.—To be of two-cylinder horizontal direct-acting type driving twin screws, each engine in a separate compartment, and specially fitted to take steam as before described. The diameter of the cylinders to be 11″ and 18¼″; stroke 14″. The valve-gears to be so designed that when working at maximum power the distribution of steam may be such that the mean effective pressure reduced to the area of the low-pressure cylinder shall be as near as may be 48 pounds per square inch, the revolutions being 195 per minute. The air and circulating pumps to each engine to be worked by an independent steam cylinder, and to be fitted to remove water from the vessel. A barrel condenser with copper shell and tube plates about 18″ in diameter and 5′ long to be fitted to each engine, located as shown.

The weight of engines, including water in condensers and pipes, feed-tanks and fresh water therein, stores, and spare parts, may not exceed 32,000 pounds.

Screws.—To be of steel, with forged boss and plate blades keyed to boss. To have 3 blades with a developed area of 4.25 square feet for each screw. Diameter, 5′ 6″; mean or uniform pitch, 6′ 6″; revolutions at maximum power, 195.

Shafting.—To be of best forged steel.

The weight of shafting, plummer blocks, stern tubes, screws, struts, and miscellaneous, not to exceed 6,000 pounds.

Total weight.—Total weight of propelling machinery as above not to exceed 26 tons.

BATTERY.

One medium power 10-inch B. L. R., to be mounted forward in line of keel on a port pivoted slide carried on V bulkheads thoroughly worked into the vessel's hull. To have a maximum elevation of 10° and depression of 2°, a gun-pit being recessed to the level of the water-tight deck to contain the slide, elevating press, &c. The gun will be worked by hydraulic pressure of about 600 pounds per square inch, a double pressure pump in the forward engine-room supplying the power. It will be served by hand with half powder charges, and the projectiles will be handled by tackle and rammed by hand or hydraulic rammer at fixed incline.

The gun will be 301″.8 long and weigh about 23 tons. The charge of brown progressive powder will be 175 pounds, and the weight of projectile 430 pounds. The estimated muzzle velocity is 1,875 feet per second, with corresponding penetration at muzzle of 18¾″ of wrought iron.

Approximate weight of gun and gear.

Gun	tons..	23
Slide with recoil presses	do...	8.5
Straps over gun, &c	do...	3.5
Elevating press, pressure pump, lead of pipes, handles, &c	do...	3.5
Gun and magazine equipment	do...	1.5
Total weight of gun and gear		40.0
Weight of fixed 2″ shield	tons..	4.75

Ammunition for 10″ gun.

Weight of one round with cases	pounds..	710
Weight of fifty rounds with cases	tons..	16
Total weight of 10″ gun, gear, shield, and ammunition	do..	60.75

Machine guns.

Four 57mm rapid-fire Hotchkiss cannon and mountings	pounds..	8,800
4,000 rounds (1,000 each) with cases	do....	24,750
Spare parts and equipment	do....	150
Total 57mm guns and ammunition		33,700
One 37mm revolver Hotchkiss and mounting (in crow's nest)	pounds..	1,000
Ammunition in cases (2,400 rounds, 40 cases)	do....	4,176
Shield	do....	750
Total 37mm gun, ammunition, and shield		5,926
Cutlasses, revolvers, and miscellaneous	pounds..	700
Total weight machine-gun battery and small-arms as above	do....	40,326
	or, tons	18.0

COAL SUPPLY.

The coal carried at load or normal displacement is 30 tons; the total bunker capacity, 70 tons.

SPEED AND COAL ENDURANCE.

With 350 I. H. P. a speed of not less than 10 knots should be obtained, under measured mile trial conditions, at the load displacement of 300 tons. At this speed 30 tons of coal would suffice for 48 hours' steaming, covering a distance of 480 knots. With 70 tons the distance covered would be about 1,000 knots.

With 170 I. H. P., which should be obtained without forcing combustion, a speed of 8 knots should be obtained in smooth water. At this speed 30 tons of coal would suffice for 135 hours' steaming, covering a distance of 1,080 knots. With 70 tons the distance covered would be about 2,300 knots.

Military mast.—A mast of wrought iron or steel pipe banded at the joints, or of other suitable construction, to be fitted, carrying a crow's nest at the top mounting a 37^{mm} revolver Hotchkiss. To be used for exhaust ventilation.

Drainage and ventilation.—A satisfactory system of drainage of the simplest possible description to be fitted, with connections to the main air and circulation pump, as well as to special donkey pump. A steam ejector may also be carried.

Natural ventilation shall be used as far as possible, but a small steam fan, with suitable connections, shall be fitted in one of the engine rooms for special ventilation of magazines and storage spaces when necessary. The exhaust ventilation of coal bunkers will require special attention.

HULL.

The hull is to be of steel of mild quality, except the superstructure aft containing the officers' quarters, which may be of composite construction, with steel frames, stringers, ties, beams, &c., with wood planking. From considerations of fire from explosion of shell it may, however, be deemed best to use as little wood as possible in this part as elsewhere in the vessel. The immersed surface will not be sheathed, as the vessel is sufficiently small to be readily hauled out for cleaning, painting, &c.

Special attention to be paid to maintaining continuity of strength, especially in the parts adjacent to the heavy gun. The rivets in the immediate support of this gun may require to be driven cold, and throughout the structure the riveting should be especially good, and as far as possible done by machine.

As little wood as possible will be used in the forward part of the vessel, and the stores and other things stowed above the water-tight deck forward should be as far as possible of an incombustible nature.

All exposed iron work above the bilges throughout the vessel to be carefully cork painted, and the bottom, floor plates, &c., up the bilges to a suitable height will be covered with a special cement composition.

A wooden chart-house will be worked forward on the upper deck, with steering wheel, annunciators, &c., but in action the vessel will be conned from within the superstructure, and steered from the wheel recessed in the main deck.

The total weight of the hull and fittings may not exceed 154 tons.

General summary of weights.

	Tons.
Hull and fittings, including all protective plating except the fixed shield to 10″ gun	154
Propelling machinery with water	26
10″ gun, mounting, ammunition, and shield	60.75
Machine-guns, ammunition, shield for 37mm, and small-arms	18
Coal at load displacement	30
Anchors and chains	2
Equipment, provisions, water, stores, &c	4.50
Complement (40) and effects	4
Boats with gear	1
Total weight or displacement	300.25

COST.

The estimated cost of hull and machinery, exclusive of armament, its immediate fittings, and ammunition, is $110,000. With armament complete, ammunition, &c., and ready for sea in all respects, the cost should not exceed $200,000.

LAKE, RIVER, AND HARBOR GUN AND TORPEDO BOAT.

GENERAL FEATURES.

The vessel to be able to pass through the locks of the Erie Canal when somewhat lightened.

To carry two 5″ B. L. R. and two 57^{mm} rapid-fire single-shot Hotchkiss cannon mounted to the best advantage.

[NOTE.—Only one 5″ gun may be carried if hereafter so decided, in which case the gun carried should command a bow fire.]

An above-water torpedo tube to be fitted in the stem in the center line, and two automobile torpedoes to be carried with the necessary equipment.

To have a single screw, but good steering power.

To carry coal enough for 1,000 miles, steaming at 8 knots.

To be fore-and-aft schooner rig, spreading at least 1,800 square feet in three principal sails. The rig to be so fitted that it may be readily removed by the vessel's complement.

To have a freeboard of about 4′ at the load displacement.

DESIGN.

A preliminary design has been made which it is believed fulfills these conditions.

Dimensions.—From a careful examination of the standard lock of the Erie Canal (see accompanying plans), it appears that the extreme length of a sharp vessel which may be conveniently taken is 102 feet, the greatest beam, 17′ 6″, while a maximum draught of 6′ may be carried through the canal without incurring delay.

The following dimensions and geometrical properties are considered well adapted to the purpose:

Length over all		102′ 0″
Length between perpendiculars		97′ 0″
Beam extreme		17′ 6″
Proportion of beam to length		1 to 5.543
Draught, mean		5′ 11″
Draught, extreme	do	6′ 3″
Displacement (sea water)	tons	128.65
Coefficient of fineness		0.448
Area of midship section	sq. ft.	84.7
Center of buoyancy below water-line		2′ 4½″
Metacenter above water-line		2′ 6″
Tons per inch of immersion	tons	2.68
Freeboard at load draught		4′ 0′

PROPELLING MACHINERY.

Boiler.—Steam of 140 pounds pressure to be supplied by a single boiler of locomotive type, about 4′ 9″ diameter of barrel and 16′ 6″ long, having a grate surface of not less than 27 square feet. To be fitted to work with steam blast in the funnel as well as with closed stoke-hole under pressure. Every precaution to insure safety to stokers in event of accident to be taken, as in first-class torpedo-boats.

Engines.—To be of vertical inverted two-cylinder compound, or of triple expansion type, as may be decided on. To be constructed throughout in the lightest manner and of the very best materials for the purpose. The pumps to be independent and fitted so that they may be used to remove water from the vessel, besides which a powerful steam ejector will be fitted for this express purpose.

Screw.—The engines to drive a single three-bladed screw of steel or suitable composition 5′ 4″ diameter and of suitable pitch.

Shafting.—To be of forged steel.

Horse-power.—The engines to be capable of developing 680 horses' power as a maximum, with a pressure in the stoke-hole of 5″ of water.

Weight.—The total weight of propelling machinery complete, with water in boilers and condenser, and all spare parts and stores, should not exceed 29 tons.

BATTERY.

To consist of two 5″ B. L. R., mounted on the upper deck, one forward and one aft, on opposite sides of the ship, with such elevation and to command such train as may be hereafter found expedient and consistent with the strength and stability of the vessel. Two 57^{mm} rapid-firing Hotchkiss cannon to be carried, mounted at points of vantage.

Weights.		Pounds.
2 5″ B. L. R. and mountings		18,800
2 shields light		1,500
120 rounds (60 each)	charge 16 pounds; projectile 50 pounds; weight of round, with cases, 80 pounds	9,600
Gun and magazine equipment		500
Total 5″ guns, ammunition, and equipment		30,400
2 57^{mm} high-power single-shot Hotchkiss and mounting		3,806
2 shields light		800
2,000 rounds (1,000 each), with cases		12,354
Spare parts and equipment		50
Total 57^{mm} guns, ammunition, and equipment		17,010

Total weight of battery complete = 47,410 pounds, or 21.16 tons.

TORPEDO OUTFIT.

A torpedo tube, fixed in the bow above water, to be fitted with discharging apparatus. Steam impulse to be used. Two Whitehead torpedoes to be carried.

Weight of one fixed tube with fittings	pounds	1,00
Weight of 2 Whitehead torpedoes	do	1,5
Weight of 2 dynamite charges	do	1
Weight of piping, spare parts, and stores	do	2
Total weight of torpedo outfit	pounds / tons	2

SPEED AND ENDURANCE.

It is estimated that the maximum horse-power of 680 will drive the vessel at a speed of 15 knots in smooth water under trial conditions.

For a speed of 8 knots about 55 I. H. P. would be required. If the total consumption for all purposes, under these conditions, be taken at 3 pounds per H. P., 10 tons will suffice for 135.8 hours steaming, or a distance traversed of 1,090 knots. With 22 tons in the bunkers, the distance steamed should be about 2,000 knots.

RIG.

To be that of a fore-and-aft schooner with sprit-topsails on fore and main, fore-staysail, and jib. The area of mainsail, foresail, and fore-staysail to be about 1,800 square feet; the total area of all the sails, about 2,400 square feet. The rig is to be as light as possible, and to be arranged so as to be readily removed with only such appliances as the vessel herself supplies, as it is not intended that the vessel shall carry any rig when in active service against the enemy. The whole weight of masts and spars, standing and running rigging, and sails, may not exceed 5 tons.

COAL SUPPLY.

The coal supply at the load displacement to be 10 tons, but the bunker capacity should be at least 22 tons. The coal to be so arranged as to afford ready supply to the fires, while its distribution should afford the maximum protection to boiler.

STEERING ARRANGEMENTS.

The vessel under steam alone is to be conned from a tower forward at the after end of the torpedo compartment. Under sail, or combined steam and sail, she will be steered by tiller on the deck aft. The lead of power from the conning tower to be worked as far as possible below the water-line. An auxiliary bow-rudder, to be lowered below the line of keel when in use, may be fitted if required.

HULL.

The hull is to be constructed throughout of mild steel of ordinary ship quality in the ingot, but of somewhat higher strength in the thin plates and sections used. The general arrangement and sizes to be as shown on the midship section, special attention being directed to obtaining the maximum of lightness and strength, and the continuity of strength being carefully maintained. Special attention is also to be paid to the local strengthening under the guns and the distribution of the stresses produced by their recoil. Complete accessibility to all parts for cleaning and painting must be obtained. A special cement composition to be worked in the lower bilge, but great care is contemplated and must be exercised to avoid corrosion. The upper deck will be covered with a rough asphalt paint or composition, so as to afford a good foothold with the least possible weight.

The total weight of hull and fittings may not exceed 57.5 tons.

General summary of weight.

	Tons.
Hull and fittings	57.50
Battery, ammunition, and equipment	21.20
Torpedo outfit	1.30
Masts, spars, sails, and rigging complete	5
Machinery with water in boilers and condensers	29
Coal at load draught	10
Equipment, provisions, stores, anchors, chains, and miscellaneous	2.50
Complement and effects	2
Total weight or displacement	128.50

Without rig, with full coal supply of 22 tons, the total weight or displacement will be 135.5 tons.

COST.

The estimated cost of hull and machinery, exclusive of guns and mountings, ammunition, torpedoes, &c., is $65,000. With armament complete, with ammunition and torpedoes, and the vessel complete for sea in all respects, the cost should not exceed $95,000.

PARTICULAR FEATURES OF PROPOSED COAST-DEFENSE VESSELS.

VERTICAL ARMOR.

The armored sides and bulkheads and turret-armor are worked in all classes in the same fashion, namely, with only sufficient wood mattress (teak should be specially obtained for this backing) to distribute the pressure from the stiff plate on impact of a projectile as uniformly as possible to the thick plating behind armor and the rigid steel cellular backing. The cellular backing on the sides is further supported by the framing of the wing passage, but the corner connections are to be so made that if the whole side be driven in under repeated shocks of projectiles the framing below the armor-shelf will be disturbed as little as possible.

To obtain a sufficient length of bolt, it is set up on a sleeve in the cellular backing with the ordinary rubber cup washer under the nut. A second washer of harder rubber is placed between the conical end of the sleeve and the plating behind armor, both for additional elasticity for the sleeve and to insure water-tightness.

The armor-plates should be of steel with a hard face, and the longest possible plates should be used. The bolts penetrate the plates from the back to a sufficient depth, and should be numerous.

The cellular backing is built up of plates and angles from $\frac{3}{8}''$ thick for 12″ armor to $\frac{1}{2}''$ for 18″, the detailed arrangement being as shown on the midship sections.

The barbette armor should be worked differently, with backing of thickness nearly equal to that of the plate. The bolt-heads to be set in a flanged cup secured to the plating behind armor, with screw-cap over the head.

HORIZONTAL AND DECK ARMOR.

To be generally worked in two thicknesses, the upper plate the thicker and of harder quality than the lower. The lower thickness to be directly connected to the beams and other supports, and the upper thickness to be connected to the lower by tap-rivets of large diameter either completely through the lower plate or with partial penetration only, as may be decided upon with regard to the cost of the work. Plates of the largest convenient size should be used. The framing and support below this armor should be as close as possible to obtain the maximum of local rigidity.

CONNING TOWERS.

The conning towers should be fitted with a spring floor and be padded breast high, the padding being screwed to a thin metal lining set off from the armor by fur-

ring-strips to provide for the escape of moisture forming on the surface of the armor. The whole inner surface must be carefully cork-painted. All apparatus contained must be supported as far as possible from the floor and not from the sides.

SUPPORTS TO BARBETTE IN 6,500-TON VESSEL.

As this barbette rests in great measure on unarmored supports, great care is necessary in their disposition to minimize the damage by shell fire. The main support should be given by curved or circular bulkheads under the armor and roller base, the plating to be lightened extensively between the stiffeners, which should be deep and heeled at top and bottom. Numerous radical brackets should be worked to these bulkheads under the barbette floor.

A large excess of support must be given to provide for the damage which must occur in action.

THE BARBETTES.

The barbette on each of the three armored vessels is designed to fill essentially different conditions.

In the larger vessel, the necessity of keeping down the dimensions, as well as the inadequacy of the 10″ gun to inflict any great damage on an enemy with armor of sufficient thickness to demand 16″ guns for its penetration, renders it advisable to carry only a single gun with only just sufficient protection and without complication of machinery in loading and handling.

This barbette, while having no unarmored supports, with consequent vulnerability from below, yet exposes the trunnions and part of the slide with shield protection only, and the top of armor is rather close to the side and water-line for the successful use of the gun in very heavy weather. To mount on this vessel two 10″ guns, as in the 6,500-ton vessel, would require an increase of displacement of about 300 tons, the other qualities of the vessel being maintained in present proportion.

In the other two vessels, the 10″ gun forms a more important part of the battery. In each two such guns are mounted. In the low freeboard vessels the guns are placed sufficiently far apart and high above the floor to allow the ammunition to be passed beneath and between the slides, and the gun can be loaded in any position of the turn-table. This could not be accomplished in the 6,500-ton vessel with the guns on the main deck without a considerable increase of armored height required. In the latter case, therefore, the guns are loaded in a fixed position, and the ammunition-hoist and loading-gear are in rear of the turn-table. In both of these mounts the men are little more exposed than in the turret. The fixed position barbette is the more vulnerable on account of the counterbalancing advantage gained of increased height of gun above the water-line, and the consequent necessity of unarmored support and liability to the mining effect of shell-fire in the confined spaces beneath it.

Each style of barbette is considered best suited to the particular vessel in which it is used.

CORK PACKING.

The space along the side where this is worked is to be closely subdivided and made water-tight, and each cell or compartment packed carefully by hand with flat

The distribution of steam to be such that, when working at maximum power, the mean effective pressure reduced to the area of the low-pressure cylinders shall be as near as may be 31.5 pounds per square inch, the revolutions being 120. Piston speed at maximum power, 720′ per minute.

300-TON GUNBOAT.

As given in general features.

128-TON GUN AND TORPEDO BOAT.

The screws to be 5′ 4″ diameter and 7′ 0″ pitch, making 293 revolutions per minute at maximum power. The developed area of screw-blades should be about 7.8 square feet.

The distribution of steam to be such that, when working at maximum power, the mean effective pressure reduced to the area of the low-pressure cylinders shall be about 51 pounds per square inch; piston speed, 750′ to 800′ per minute.

The screw of small diameter required by the limited draught of water works with so much slip at maximum power that it may be desirable, in the preparation of building plans for this type, to increase the load-draught aft sufficiently to admit a somewhat larger screw. It will not, however, be advisable to carry a screw of more than 6′ 0″ diameter.

We have also received the following manuscript reports and drawings, which we desire to append to our report:

(1) Counterpoise Platforms for Heavy Guns. A. T. Brewer. 1873.

(2) A Depressing Gun-Carriage for 10-inch Rifle. Lieut. Col. A. R. Buffington, Ordnance Department. July 7, 1885.

(3) Memoranda on Counterpoise Gun-Carriages. Maj. W. R. King, captain of engineers. October 15, 1885.

Four different kinds of carriages are required for modern sea-coast guns: (1) For use in revolving turrets; (2) for use in casemates; (3) disappearing carriages for barbette batteries, fixed turrets, and shields; and (4) for the old form of barbette battery where the guns remain always in view.

It is essential that embrasures, whether in turrets or casemates, shall offer as small a target to the enemy as possible. This condition compels the placing of the center of motion at or near the throat, and hence the raising and lowering of the whole gun and carriage by suitable machinery. In a revolving turret this motion is confined to a vertical plane passing through the axis of the piece; in casemates, provision for horizontal motion about a vertical pintle below the throat must also be made in order to secure the needful traverse.

The essential difference between the first and second types of gun-carriage is therefore the greater complexity of the latter caused by this horizontal motion.

The importance of disappearing carriages for use in barbette, although recognized for many years, has been made more conspicuous of late by the introduction of machine guns and the improvements in shrapnel firing. The increased length of the guns and the greater distance of the cannoneers from the parapet required by the adoption of loading at the breech have also contributed to the same result. It may now be regarded as an essential condition that important barbette guns, on low sites and likely to be exposed to a heavy fire, shall be thus mounted. Our barbette batteries planned since 1871 have all been constructed to meet this condition, although no pattern of carriage to effect the object has yet been adopted.

The disappearance of the gun may be effected upon six different principles, and patterns of carriages based upon each of them have been proposed. These principles are:

(*a*) The raising and lowering of gun, carriage, and platform by suitable machinery. Two 11-inch guns have been thus mounted, on the Pauker system, at Fort Constantine, near Cronstadt, for several years; and Mr. A. L. Brewer, superintendent of the arsenal at Watertown has proposed a carriage of this type.

(*b*) Revolving the gun downward about a horizontal axis, fixed or movable, parallel to the parapet. The Moncrieff hydropneumatic carriage, the Rendel carriage, the Raskazoff carriage, the Albini carriage, the Ridgway revolving battery, and other types proposed for large calibers and revolving about a fixed axis are known types. Colonel Buffington has proposed a carriage with a movable axis.

(*c*) Allowing the gun, when fired, to slide to the rear, down an inclined chassis, at the same time raising a counterpoise, by which it can again be drawn up at pleasure. Major King's carriage is a well known example of this class, and 15-inch 25-ton guns were successfully mounted upon it shortly after the close of the civil war.

(*d*) Rolling the guns to the rear on eccentric wheels. This was the idea embodied in the carriage invented in this country by Colonel De Russy in 1835, and more recently by Colonel Moncrieff in England. Many 7-inch rifles are thus mounted to-day, but for larger calibers the plan has been found to be mechanically impracticable.

(*e*) Revolving the gun to one side about a vertical axis, thus removing it from its exposed position to one under cover. This idea has only been developed for small guns.

(*f*) Revolving the gun downward about a fixed horizontal axis perpendicular to the parapet, a method only suited to small guns.

But little need be said about the ordinary non-disappearing barbette carriage. Many well-known types are in use. The various methods of taking up the recoil are the chief distinctive feature. The type of Vavasseur carriage, now meeting with general favor, possesses the merit of opposing a uniform hydraulic pressure at all parts of the movement, thus reducing the recoil within narrow limits without throwing an excessive stress upon the top carriage or platform. From high sites these guns can be served with moderate risks if furnished with suitable steel breech-hoods.

It is impracticable without elaborate drawings to make the details of modern gun-carriages intelligible. Moreover, the scope of our duties does not include a technical treatment of the subject. Your committee, therefore, confine their report to this general presentation, and to the expression of opinion that the present condition of the carriage problem is as well advanced as that of the guns themselves. There will be no mechanical difficulty in mounting modern cannon in a suitable manner upon any of the four systems needed for coast defense.

HENRY L. ABBOT,
Lieutenant-Colonel Engineers, Chairman.

APPENDIX 1.

DESCRIPTION OF BREWER'S COUNTERPOISE PLATFORM.

Considerable attention has been paid of late to the subject of counterpoising guns and gun-carriages for garrison and siege purposes, so that the gun may be lowered behind and below the parapet to be loaded, and raised above the parapet to be fired. Heretofore inquiries and experiments seem to have been confined to counterpoising guns and their carriages only.

My invention has reference to counterpoising, lowering, and raising, not only the gun and carriage, but the platform on which they rest, thus obtaining more steadiness and uniformity of action, and more certainty of control, as I think. I am also enabled to use the carriages as already constructed and now in use.

I accomplished my object by placing the platform upon one end, or ends, of a series of levers, having upon the other end, or ends, a counterpoise weight, and then, by the transference of an additional weight from one to the other, causing the platform to rise or fall, as desired.

In the drawings—

Plate 1 is a top view of gun and platform.

Plate 2 is a perpendicular sectional view of gun, carriages, platform, levers, weight, &c., when the gun is elevated and in battery.

Plate 3 is a like view when the gun is depressed and recoiled.

Plate 4 is a top view of the lower system of levers, &c.

A A is a platform upon which is placed the ordinary revolving chassis carriage B B, and upon that the top carriage C, upon which last is the gun D. The drawings are made on a scale of one thirty-second to the inch of a 15-inch gun. The pintle *a* is made hollow. *o p n* represent the three circles upon which the revolving carriage B traverses upon the wheels *q r s* (*s* having an eccentric axis). *t t* are the eccentric axle-wheels of the top gun-carriage C.

Directly in front of the pintle in the center of the carriage B, under the gun, is placed a pulley, *b*, having its center on the bottom rails of the carriage, and at the front is placed another pulley, *c*, having its center midway the rails.

On the lower side rear end, midway of the carriage C, is fastened a guide-rod, *d*, surrounded by a stout cylinder or hollow rod, *v*, which is surrounded by a strong spiral spring, *w*.

To the hollow rod *v*, at its front end, is attached a cord or chain, *k*, passing forward over and around the pulley *c*, and over the pulley *b*, and down through the pintle *a* to the auxiliary or transfer weight K.

The platform A is mounted or suspended on a series of rods, E, pivoted by knuckle-joints, *e*, to the platform at their upper ends, and at their lower ends by joints *f*, to a series of levers, F.

These levers F are hung midway, at *g*, to strong supports G.

At the inner ends of these levers F are hung rods *h*, pivoted to the levers at *j*, and extending downward and pivoted at *x* to the counterpoise weight H, which is equal to the combined weights of gun, carriages, platform, &c., so that the platform will rest at any position, up or down.

At the inner extremities of the levers F is placed a small platform, I, having, extending below, brackets or projections J, in which are placed friction-rollers *i*, resting on the tops of the ends of the levers F, and supporting the platform I.

K is a transfer weight attached to the cord or chain *k*, and pulling against the spiral spring *w*.

L is a strong-walled well, of suitable depth, in which the platform A rises and falls.

N are pillars, having upon their tops rubber or other suitable seats, upon which the platform rests when depressed.

M is a strong walled shaft in which the weight H is placed, and moves up and down.

In the walls of this shaft are placed projecting pillars with grooves *m*, in which move tongues upon the weight, for steadying purposes. *n* are tongues or tenons attached to the walls L, and fitting into corresponding grooves or mortises in the circumference of the platform to steady the platform. Friction-rollers will be used on these tongues and grooves.

When the gun is in battery the parts occupy the positions in Plate 2. When the gun is fired it recoils backward, and in so doing lifts the weight K from its platform I (where it rested upon the counterpoise ends of the levers), as shown by the dotted lines, Plate 2, and so transfers it to the platform end. As a result, the platform end becomes so much the heavier, and, as the gun goes back to the rear of the chassis carriage, the platform end sinks and the counterpoise rises till they occupy the positions shown in Plate 3. The gun is then held in position for loading in the usual manner.

When loaded and the friction released, the gun rides forward, and the weight K, being deposited on its seat I on the counterpoise end of the levers, that becomes so much heavier and sinks, while the platform rises as the gun rides forward into battery, as shown in Plate 2, when it is ready to be fired.

The distances from *e* to *f*, and *f* to *g*, and *g* to *j*, and *j* to *x*, are intended to be equal. If the counterpoise is made exactly to balance the platform, carriages, and gun, it will be seen that, when the gun is loaded, considerable weight will be added to the platform end of the lever. The charge of a 15-inch gun will weigh some 600 pounds. In practice it may be found desirable to increase the weight of the counterpoise about one-

half the weight of the charge, and the transfer or make-weight should probably amount to 1,200 pounds, or thereabouts. These weights may be regulated as experience may require.

The first shock of the recoil is relieved by the spiral spring acting against the transfer weight as it rises, and this weight moves more steadily and without jerking. The bearings should be knifed-edges, and the levers and rods must be trussed, or otherwise made of strength enough for the purpose. The parts can be made of any suitable materials, and strengthened as found desirable.

My intention is to furnish the platform with friction bands, and levers, and ratchets, and pawls, so as to be able to stop it and to hold it at any point, and also to ease its ascent or descent. The recoil of the gun taking it down, and the bringing it into battery carrying it up, no extra men or extra maneuvering or manipulations by the men will be required in handling the piece.

The transfer of the auxiliary weight by other means will not change the principle of my invention.

A front pintle carriage may be used as well, or, indeed, any kind of a carriage, the proper modifications being made, while the general principle, plan, and mode of operation remain the same.

A. T. BREWER.

It is presumed, however, to be sufficiently in detail to enable a judgment to be made as to merit; as to adaptability to open batteries and positions, exposed to influences of weather, &c., destructive to more delicate mechanisms, and as to being more suitable than these considered in relation to the conditions of our service, which require *serviceability* after long exposure and want of care.

The simplicity of the construction permits of indefinite expansion *as to strength* and size, and therefore it is suitable for the heaviest as well as the lightest guns.

The drawings represent a carriage for a 10-inch high-power B. L. rifle of 27 tons, and a breast height of 12 feet 9 inches. The mechanical means for handling the gun—running to and from battery, traversing, elevating, and depressing—consist of certain chains or ropes below described and a doubly worm and geared windlass at the rear of chassis operated by cranks, one on each side, in convenient position. The wire or other ropes or chains shown in drawings on the sides of chassis—connected with the gun at the trunnions and top carriage and chassis—are connected with the windlass for running the gun to and from battery. These pass around—have a "bight" on—free pulleys on the ends of windlass arbor outside and close to the chassis rails. The pulleys are held by pawls, which secure the gun after recoil from returning to battery, and are secured to the windlass by a clutch when it is necessary to use the windlass for further depression after recoil, or for depression when drilling. These chains or ropes serve in like manner to supplement any failure, on account of rust, want of oil on the bearings, or other cause, of counterpoise to put the gun fully into battery.

The windlass arbor carries a beveled gear, engaging with another on a shaft, between the chassis rails, perpendicular to it, which shaft can be connected at will by a clutch to a free pulley on it carrying the chain used for traversing. This chain, the ends of which are made secure at the limits of traverse, lies on the platform between the pintle and traverse circle at the foot of a circular step of stone which bears the stress of chain tangentially when the gun is traversed. For elevating and depressing, a rope is shown attached either to eyes or hooks made fast to the gun, or to hoops around the gun, in front and rear of trunnions. This rope passes under, through pulley-blocks, the top carriage, and goes back and forth with the gun, and to it, by a clutch, a loose rope is attached, and a "bight" taken on the windlass for depression or elevation—to the front for depression, to the rear portion for elevation. To secure as much protection by the breast-height as possible to the gun when out of battery, the drawings show that depression for low firing must be given after the gun is in battery. To do this the loose rope would be attached well forward to the one passing under the top carriage and allowed to go forward with it into battery, the other end being retained at the windlass. In like manner the gun may be elevated when in battery if found necessary or desirable. The degree of elevation or depression is indicated by pointers on the trunnions and graduations on the trunnions' beds of top carriage.

This method of elevating and depressing presumes the gun to be entirely without preponderance and weight of charge insufficient to overcome the friction on the trunnions. There are other methods that may be found more desirable should a carriage be built; but this one is simple, without machinery, and seems to possess the requisites

of power and rapidity. The cranes at the rear of the carriage are constructed to utilize, by the means shown, the recoil in raising the charge on one side and the projectile on the other for loading. The arrangement of differential pulley-blocks and chains connected with the cranes explains itself. All of the ropes and chains are detachable and can be removed for preservation and storage.

Instead of the counterpoise being above ground, as originally proposed, it is now placed below, under the pintle, which is hollow for the passage of a piston-rod attached at one end to the yoke of the gun-supports of upper carriage, and at the other to a head supporting the counterpoise—lead plates arranged as shown in the drawings. The counterpoise chamber is a cast-iron cylinder, which can be made in sections, as shown, and bolted together, about 13′ 4″ × 4′ diameter, for a 27-ton (2,240 pounds) gun, the counterpoise occupying about 6 feet of the height.

For a center pintle carriage the piston-rod would become a wire rope carried from its attachment to the yoke over a pulley at the front of carriage to another over the pintle, through which it would pass to its attachment to the counterpoise. To apply the aforesaid discussion to the recoil of a gun of 27 tons, throwing a projectile of 575 pounds with a velocity of 1,850 feet, the expression for the $\int ds.\ P = \frac{M.\ V^2}{2} = \frac{W.\ V^2}{2\,g}$ amount of work would become by substituting the value of W (=60,480) V (=17′.56), and g (=32) $\frac{60480 \times \overline{17.56}^2}{64} = 291{,}438$ foot-pounds, and the sum $\frac{W}{R}\,\tilde{n}\,\frac{R^2}{4} - \frac{W.\ R}{3}$ (R being 6 feet and ñ, 3.1416), 164,046 foot-pounds, neglecting decimals in both cases. These results added give 455,484 foot-pounds of work to be overcome by recoil checks. Divide this quantity by seven, and the result—65,069 + pounds—raised seven feet, would require an expenditure equal to the work required of recoil checks. By the construction, however, the counterpoise does not move fully seven feet; but this does not affect materially the result arrived at. The gun and counterpoise supports, 13 feet long from center of trunnions to center of yoke bearings, turn around the ends of the top carriage front axle, the center of the ends of which are 6 feet from the centers of the gun-trunnions and 7 feet from the centers of the yoke ends. Taking six-sevenths of 65,069, the result, 55,773 pounds for a counterpoise, would be about what would be required, taking account of friction, to run the gun *charged* into battery from the loading position. The counterpoise or piston head having a face of 1,809 square inches, the pressure of but four atmospheres would equal 108,540 pounds, which would very rapidly increase at the very last instant of recoil. This will be readily appreciated by a consideration of the relative movements of the gun and counterpoise. When the latter has traveled but half of its path the gun is near the completion of recoil; therefore during the remaining short portion the pneumatic buffer is brought into most effective action, which would oppose the acquired living force of gun and counterpoise aforesaid.

Respectfully, your obedient servant,

A. R. BUFFINGTON,
Lieutenant-Colonel of Ordnance, Commanding.

It was not understood that I was to devise a carriage complete in all its details and proportions; but what I expected to do was simply to ascertain whether a carriage could be so arranged that it would allow one of our heaviest guns to recoil down an inclined plane and there be stopped without shock, loaded under cover, and then brought back up this incline to its firing position, thus dispensing with iron shields, and becoming to that extent a substitute for both fort and armament, as they then existed.

For this reason, as well as to avoid expense, I made as few changes as possible in the fort and old carriage selected for the experiment; but in order to forestall the objection always raised in cases where experiments are made on a reduced scale—viz, that the results would not apply to guns of larger dimensions—it was decided that I should make the experiment at once with one of the largest guns in service.

II.—Description of the Existing Carriage.

The following brief description of this carriage, as it now stands, is essentially the same as that given in General Gillmore's Annual Report, Appendix 2, Report of Chief of Engineers for 1881:

The drawing (Sheet II) will be understood by those familiar with the ordinary carriages without a detailed description.

The pintle block, traverse circles, traverse wheels, props, and chassis are like the old ones, excepting that the chassis is longer and slopes 20° to the rear, the front end being raised about 7 feet above the pintle block.

The pintle is hollow, 10 inches inside diameter, and 1 inch thick.

The counterpoise is made, for convenience in handling, in disks 1 foot thick, and moves in a well 13½ feet deep under the pintle block. The pulleys in the counterpoise and chassis are grooved for four 1¾-inch wire ropes. These ropes are made of six strands, with nineteen steel wires to the strand, and a core of soft iron wire. The ropes are of equal length, and can be fitted with iron knobs at the factory so as to require no adjustment after they are put in place. One end of each rope is held by a socket at the front of the pintle block, and the other by a socket hinged to the under side of the top carriage, near its front end.

The top carriage is so made that when the rear truck wheels are thrown "in gear" the weight of the gun is thrown upon the front wheels also—in fact over two-thirds of the weight then comes upon the front wheels; but when "out of gear" nearly the whole weight slides. The throwing into and out of gear is done by two or more men turning the hand-wheels at each side and just below the breech of the gun; and the weight of the counterpoise is such that when in gear the gun will run up into battery; but when sliding, as during recoil from firing, the top carriage will remain wherever it stops.

The elevation of the gun, in "pointing," is given by the same hand-wheels, the operation being controlled by the gunner, as shown in the plate, while two other men turn the wheels.

In loading, Nos. 1 and 2 stand upon a platform inside the chassis, and the shot is rolled to them from a rack along the breast-height wall. Both elevation and horizontal direction can be given while the gun is under cover of the parapet; and, as suggested

As a general result of these experiments, I felt satisfied, and have never seen the slightest reason to doubt the conclusions then drawn, that the counterpoise system was not only perfectly feasible, but beyond all question the most practicable one that had been devised for securing additional cover for heavy guns mounted en barbette. I believed that I had accomplished all that I was required to do, and that the necessary details for the building and maneuvering of these carriages would be supplied during the process of construction, as had been done in case of the ordinary carriages.

SECOND TRIAL.

On the 23d of August, 1869, the Board of Engineers for Fortifications, who had been directed to test and report upon this carriage, doubtless with a view to its availability as a substitute for armor-plating, &c., assembled at Fort Foote and witnessed the firing described in their report, as follows:

NEW YORK, *August* 26, 1869.

GENERAL: In compliance with Special Orders No. 83, Headquarters Corps of Engineers, dated August 13, 1869, the Board of Engineers respectfully report that they repaired to Fort Foote on the 23d instant and witnessed four firings of the 15-inch gun mounted on Major King's counterpoise carriage, the details of which are given in the statement herewith.

The three firings with solid shot of 432 pounds weight, and maximum powder charge of 100 pounds, and elevation of 30°, 15°, and 10°, respectively, taken in connection with the previous firings made by Major King. indicates, so far as the limited number goes, a successful application of the method of counterpoise. But, considering the liabilities to rupture of any rope connection forming a medium for the transmission of motion to such ponderous masses, such success cannot be considered established until the firings have been continued to a number of rounds greater than would be fired in an actual engagement.

In the auxiliary arrangements there were defects fairly attributable to the usual imperfections of new designs, and of an apparatus not very perfectly made.

The Board recommends the continuance of this experiment, and that authority be given to Major King to repair his carriage, in order to continue the tests, remarking that increased facilities for loading and manipulation, and a greater fall below the crest, such as he proposes in his new design, would be indispensable in new constructions.

The Board further remarks that though the dismounting of the gun by the fourth discharge was due to causes quite independent of the essential features of the carriage, it furnishes an additional reason for so modifying it that the muzzle shall not strike on a cross-bar in recoiling.

Respectfully submitted.

J. G. BARNARD,
Col. and Bvt. Maj. Gen.
GEO. W. CULLUM,
Col. of Engrs. and Bvt. Maj. Gen.
H. G. WRIGHT,
Lt. Col. of Engrs. and Bvt. Maj. Gen.
Z. B. TOWER,
Bvt. Maj. Gen., U. S. A.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

In accordance with these recommendations, I was directed to make the necessary repairs and changes in the carriage, and when these were completed, and a few rounds had been fired, nothing further was done in the matter for about a year, after which the same Board was directed to make a third trial of the carriage, which took place on the 2d of May, 1871.

THIRD TRIAL.

The results were decidedly favorable; but, in order to afford a better opportunity for testing the possible effect on the rope, of traversing the gun to extreme limits, the Board recommended that the carriage be removed to a point where there was a broader horizontal field of fire than at Fort Foote.

FOURTH TRIAL.

In accordance with this suggestion, the carriage was removed to Battery Hudson, New York Harbor, where it now stands, and after the emplacement and carriage had been prepared, and the gun mounted, another trial was ordered August 4, 1871, before a mixed board, consisting of Generals Hunt, Gillmore, and Seymour, and Colonels Laidly, Crispin, Baylor, and Dupont, who were ordered to fire at least 100 rounds from the gun, and make such further tests as they might deem necessary.

Certain defects in the details of the carriage having been developed, the Board adjourned soon after it met, and was reconvened December 4, 1871, when the experimental firing was resumed, and continued until December 23, 1871, when the report of the Board—which covers some 35 pages of legal cap—was submitted.

This report was made in the form of resolutions, which were voted upon, and passed or rejected, according to numbers voting for or against them.

Among the resolutions which passed by a unanimous vote was the following:

Resolved, That King's counterpoise gun-carriage for the 15-inch Rodman gun, after sustaining more than 100 rounds, fired with 100 pounds of powder and solid shot, at every possible angle of traverse, and at the elevations common and usual in action, varying from 3° depression to 30¼° elevation, is pronounced by this Board to be in a fit condition for immediate service with the same charges and under the same conditions with regard to elevations and directions.

The following was passed by a vote of 5 to 2:

Resolved, That in the judgment of this Board it is inexpedient and unwise at present to adopt any gun-carriage for heavy guns until after extended and careful comparison by competition with other projects yet untested, and therefore that King's carriage, however favorable the results of the tests already applied may be deemed, cannot be recommended for adoption.

Also, by same vote:

The Board is of the opinion that the question of the adequate and suitable protection of our guns, carriages, and cannoneers, is only to be solved by the competitive trials recommended in the foregoing proceedings, and that these trials should be inaugurated without delay.

FIFTH TRIAL.

In October and December, 1872, Generals Newton and Gillmore fired 10 rounds from the gun on this carriage for the purpose of testing the force and direction of the blast of heavy guns. Four of these rounds were fired when the chassis was traversed fully 70° from the perpendicular, the traverse circle being lengthened out for that purpose, which gave the greatest possible inequality of strain upon the ropes.

No difficulty was experienced in firing these rounds, either by the cannoneers or to the carriage.

SIXTH TRIAL.

In January, 1873, another Board, consisting of Generals French, Wright, and Tidball, and Colonels Flagler and Benjamin, was convened "to examine and report upon plans and models of such depressing and other carriages for heavy ordnance as the Board may deem worthy of trial." The Chiefs of Engineers and of Ordnance were directed "to lay before the Board all papers bearing upon the subject."

This Board examined a large number of devices for mounting heavy guns [see Report, Chief of Ordnance, 1873], and on February 17, 1873, the Board proceeded to Fort Wadsworth, New York Harbor, and witnessed the firing of the 15-inch gun mounted on King's depressing carriage. Full service charges with solid shot were used. Four shots were fired at different elevations. Captain King, U. S. Engineers, arrived just before the second shot was fired. The gun detachment, though not familiar with the mechanism of the carriage, nor the method of loading a gun mounted upon it, seemed to find but little difficulty in maneuvering or loading.

The Board then adjourned.

NEW YORK CITY, *February* 18, 1873.

The Board met pursuant to adjournment.

Present, all the members.

The proceedings of the previous day were read and approved.

The following resolution was offered, and carried unanimously:

Resolved, That the Board, being of the opinion that the depressing carriage devised by Capt. W. R. King, U. S. Engineers, has already been sufficiently tested, and has been proved to be a good and reliable carriage for heavy guns, well adapted to certain localities, does therefore recommend that this carriage be subjected to such further trials as may be deemed necessary to determine its merits as compared with those of other carriages for heavy guns.

The carriage, as it now stands, has been tested to the extent of 167 rounds, of which 145 were fired with maximum charges, viz, 100 pounds mammoth powder, and with the exception of 21 rounds, in which shell were used, the firing was with solid shot of 432 to 450 pounds weight.

No proper test of the rapidity of fire was made, as none of the detachments were specially drilled at this carriage, and different details were made each day of the firing.

It was found, however, that these men could load and fire in two minutes, and with properly drilled detachments this time could doubtless be considerably reduced.

IV.—OPINIONS OF OTHER OFFICERS

The following letter and the replies thereto will need no explanation, as the lapse of nearly fourteen years since they were written, and the fact that, though personal, they were not confidential, will obviate the necessity of getting special permission to use them in this connection:

TOMPKINSVILLE, S. I., N. Y., *January* 5, 1872.

DEAR SIR: I am desirous, as a matter of personal satisfaction, to have the opinions of those who have seen the practical working of my counterpoise gun-carriage, upon its practicability and value as a part of our sea coast armament.

Will you be kind enough to send me a few lines expressive of your opinion on the subject (whether favorable or otherwise), and oblige.

Very respectfully, your obedient servant,

W. R. KING,
Captain, Corps of Engineers.

COLD SPRING, N. Y., *December* 26, 1871.

DEAR SIR: * * * I think your plan for this carriage is the best which I have any knowledge of being tried; and the tests to which it has been subjected are certainly sufficient to show that it is practically successful.

* * * * * * * * *

Yours, very truly,

R. P. PARROTT.

Maj. W. R. KING.

NOTE.—In addition to being a distinguished inventor of guns and carriage himself, Captain Parrott was probably as good a judge of such matters as any man in the United States.

W. R. K.

FORT WADSWORTH, N. Y. H., *January* 6, 1872.

DEAR MAJOR: In reply to your note of the 5th instant, I take pleasure in stating that I had opportunities of witnessing the practical working of your counterpoise gun-carriage during the recent experiments at this post, and so far as these opportunities enable me to judge, I am decidedly of opinion that it is practical and much superior to any carriage now in service.

The ease and rapidity with which the carriage can be maneuvered gives a greater rapidity of fire and accuracy of aim.

The service of the piece on this carriage is simple, and cannoneers, I think, can be more readily instructed in their duties with it than with the old carriage, while the safe cover afforded by the parapet will enable them to perform their duties at all times, under all circumstances, with composure.

Whether or not it be found to meet all the requirements of the service, to my judgment it possesses great merit as a part of our sea-coast armament over anything we now have.

Very respecfully, your obedient servant,

ROYAL T. FRANK,
Captain, First Artillery.

HEADQUARTERS FORT WADSWORTH, N. Y. H., *January* 8, 1872.

MAJOR: Yours of the 5th instant is received. As I saw but little of the experimental firing of the Board with your counterpoise carriage, I am not able to give a very satisfactory or intelligent opinion of its merits. At the same time I think it is a very great improvement on the old pattern, but would hardly say it should be adopted to the exclusion of *all* other carriages for sea-coast defense, until further experiments are made.

Very truly, yours,

JOHN M. BRANNAN,
Major, First Artillery, Bvt. Maj.-Gen'l., U. S. A.

Maj. W. R. KING,
U. S. Army.

FORT FOOTE, MD., *January* 9, 1872.

MY DEAR SIR: I will state in reference to your letter of the 5th instant, making inquiries as to my judgment upon the practicable working and value of your counterpoise gun-carriage, that as far as my observation went, I was strongly impressed in its favor.

The simplicity and strength of its construction, the ease with which it was manipulated by enlisted men entirely undrilled at it, and the efficient manner in which recoil was taken up, surpass, in my judgment, any of the parallel results in carriages for the 15-inch gun heretofore built upon different principles.

When the lowering of the gun to a level, where it can be loaded under cover, is added, the superiority of your carriage is immeasurably advanced. I have personally witnessed the trial of carriages when the force of recoil was attempted to be controlled by long and short air-cylinders, by elliptical springs producing vertical friction surfaces, and by Smoot's adoption of Ericsson's principles of compression, in addition to sanded rails, as well as with the upper carriage resting entirely upon truck-wheels, 14 in number, I think.

None of them appeared to work as simply or as successfully as your arrangement. In fact, most of them are wrecked after a few rounds. I had some doubts upon the durability of portions of your carriage, but if it withstood successfully 154 rounds, I think I may regard them as removed.

I believe that with your carriage, or rather for it, the hitherto unaccomplished fact of a durable platform will become a possibility.

* * * * * * * * *

Very truly, yours,

J. B. CAMPBELL,
Captain, Fourth Artillery.

Capt. W. R. KING,
U. S. Engineers.

FORT WADSWORTH, S. I., N. Y., *January* 10, 1872.

DEAR SIR: I take pleasure in saying that I was in charge of a gun detachment at this post, by whom about fifty shots were fired with your new counterpoise gun-carriage, and from the great facility with which it can be handled, and the safety and confidence given the men, and the simplicity of its construction, and the ease with which it accomodates itself to opposed and extreme tests, I am of opinion that it is the best device of the kind the world has seen, and would be invaluable in the defense of our sea-coast.

Very respectfully, yours,

A. H. MERRILL,
First Lieutenant, First U. S. Artillery.

Capt. W. R. KING,
Corps of Engineers, U. S. A.

FORT WADSWORTH, N. Y. H., *February* 23, 1872.

SIR: In answer to your communication in regard to the working, &c., of the "counterpoise gun-carriage" of your invention, I have the honor to state, that I was in command for several days of the detachment detailed to act as cannoneers during the experiments before the Board of officers.

This carriage is superior to any that I have seen for heavy guns. Its protection to the cannoneers while loading, and the facility with which it is "run in" and "from battery," the rapidity with which the piece can be loaded and fired, and also its simplicity in maneuvering, being easily taught to and understood by the men, are among the many advantages it possesses over the other carriages for heavy guns now in use.

I am, major, very respectfully, your obedient servant,

R. H. PATTERSON,
Second Lieutenant, First Artillery.

Capt. W. R. KING,
Corps of Engineers, U. S. A.

V.—ADAPTATION OF THIS CARRIAGE TO GUNS OF INCREASED WEIGHT AND LENGTH.

The most radical changes made in heavy ordnance since this carriage was completed have been in the general introduction of the breech-loading system and the greatly increased weight and length of guns. In fact, so far as length is concerned, they are fast coming back to the primitive culverin, which was sometimes over 50 calibers in length. After a reduction to only about 15 calibers, in the last fifteen years guns have increased again up to 35 calibers in length.

To provide for this additional weight and length, as well as for a still greater height of parapet, as suggested by the Board of Engineers for Fortifications, the following changes in details and dimensions have been made, reference being had to Sheet III:

(1) The chassis is lengthened and made stronger and heavier, and its slope is increased to 24°, or 4° more than in the design for 15-inch guns.

(2) The top carriage is also made larger and heavier, and the trunnion-beds are moved 2 feet back and provided with strong iron links, which allow the gun to rise when fired at low elevations.

(3) These links are connected together with a strong curved guide-piece, shaped like the letter Y, passing under the gun, and so arranged that when the gun rises the axis of the trunnions will remain horizontal, and the gun will be caught at whatever point it may reach and lowered easily back to its place in the trunnion-beds.

(4) An automatic arrangement can also be added that will cause the muzzle of the gun to rise or fall as soon as the recoil begins, so as to cause the muzzle of the piece to clear the parapet when fired in a horizontal position or come down to a proper loading position when fired at high elevations. This was designed for the original carriage but never applied.

(5) The counterpoise is increased in weight and the ropes and pulleys are made stronger. It should be noted in this connection that the increased weight of the gun, although requiring a stronger rope to hold it in position, does not cause a proportionate increase during recoil, since the shock of the recoil is greatly reduced by the inertia of the additional mass.

(6) Owing to this increased weight of gun, the tendency to recoil will also be greatly diminished, while the friction, which resists recoil, will for the same reason be increased, and these two causes would reduce the amount of recoil so that the gun would not come under cover; but this can be provided for by allowing a considerable portion of the weight of gun and top carriage to rest on the front wheels during the first 12 or 15 feet of recoil, and then arrange for sliding friction until the gun comes to rest.

(7) If the carriage is to be worked by steam power, it can be traversed each time to the loading shelter for loading, but if served by hand it might be loaded from a light loading truck, Fig. 2, Sheet III, which could carry the shot and charge directly to the breech of the gun, and afford a suitable platform for the men to stand upon during the operation.

VI.—Application of Steam-Power.

The question as to whether steam-power can be applied to this carriage with advantage has been carefully kept in view ever since the first drawings were made, and there is not the slightest difficulty in the way, excepting that heretofore there appeared to be no necessity for it. The 15-inch 25-ton gun on this carriage can be served by hand as rapidly as it can be fired with proper deliberation, and as easily at least as on the ordinary carriage, while the number of cannoneers is not increased, and, being in much more sheltered positions, they can perform their work with comparative coolness and efficiency. As the number that can be used to advantage will not exceed ten to each gun, it is evident that a battery of ten or twelve guns will not have more, if in fact as many, men about it, as will be needed to prevent the guns from seizure by small assaulting parties, and it is quite likely that a large additional force of soldiers, though not necessarily artillerists, will be required at each battery to protect the guns, guard the land front and its approaches, and attend to police duty.

Many of these troops will be available, if needed, for serving the guns, and they will be in much better *morale* if kept thus employed during an engagement than if held as idle spectators or concealed in bomb-proofs.

However short the notice in any future emergency, the number of troops available for any defensive operations in our sea-coast batteries will, in all probability, be so great that the difficulty will not be how to get soldiers, but *how to employ those who offer their services.* It is evident, therefore, that even if it took 50 men to each gun there would be no difficulty on the score of *numbers*, and it would only be a question of whether they could be so employed as not to be in each other's way, nor unnecessarily exposed to the enemy's shot On the other hand, even if steam-power could be so arranged that one man could work a whole battery, there would be no advantage in such a system, as it would be trusting too much upon a single chance.

With the modern guns of 50 to 100 tons' weight, however, the matter assumes a different aspect, and it becomes doubtful whether man-power can be relied upon to handle such enormous masses with sufficient rapidity to deliver a heavy fire with such guns, even if the number of men is almost indefinitely increased.

There is no mechanical difficulty in the way of applying steam-power to this carriage, and I have made a sufficient study of the subject to see exactly how it can be done, and that the cost will not be great, nor the machinery complicated.

Without going further into details than to explain the general features of the system, it may be stated that the following conditions are sought to be fulfilled:

(1) That the prime motor, which must be a steam-engine and boiler, should be located at a central point, securely sheltered, and as far as practicable from the magazines and loading shelter.

(2) At least 10 or 12 guns should be worked from the same engine

(3) The power should be transmitted to the gun-carriages in a simple and effective way, that cannot be interrupted by the enemy's shot; and if one gun is disabled it must be at once detached from the system, so as not to interfere with the service of other guns.

(4) The power should be so applied to each carriage as to be under absolute control of one man on the spot, and who can thus follow the movements of his gun as well as those of the enemy.

(5) The medium best adapted to transmitting power in this case is either compressed air, or oil, or glycerine and water, or some other cheap non-freezing liquid under high pressure.

(6) In either case a strong reservoir is required, and the fluid must be forced in by the prime motor; but if a liquid is used this reservoir must consist of a strong cylinder and heavily loaded piston, on the well known principle of Armstrong's "Accumulator."

(7) There should be at least two small but powerful direct-acting force-pumps in either case—three would be better—so governed automatically that they will keep the pressure up to a certain point and stop when that point is reached. Engines are in quite general use for similar purposes, and several patterns of them are on the market.

(8) The following dimensions will be sufficient for the different parts of the machinery for a 12-gun battery, if hydraulic transmission is employed:

(*a*) Two twenty-five horse-power steam boilers, locomotive pattern.

(*b*) Two direct-acting steam pumps, 18-inch steam cylinders and 6-inch plungers.

(*c*) One hydraulic accumulator, with 20-inch cylinder, 10 feet long, loaded to 1,200 pounds per square inch.

(*d*) A tank of boiler iron, of a capacity somewhat larger than that of the accumulator, to receive the liquid after it has been used and returned from the guns.

(*e*) A sufficient length of hydraulic pipe, about two inches in diameter, to connect the accumulator with each gun, as shown on Sheet IV, and an equal length of ordinary water pipe to return the liquid to the tank just described. The hydraulic pipe should be tested to about 2,000 pounds per square inch, and both pipes, leading to and from each gun, should be buried in deep trenches, so as to be as secure as possible from frost and from the enemy's projectiles.

(*f*) Each gun carriage should be provided with hydraulic cylinders and pistons, so disposed as to enable the gunner, by simply opening a valve, to traverse the gun, give it the desired elevation, or run it to or from battery, in case the counterpoise or recoil fails to bring it to the proper firing or loading positions.

(*g*) Finally, each carriage should be provided with implements for working it by hand, in case of accident to the hydraulic machinery.

The details of the various parts of this apparatus would be neither complicated nor expensive; and, as many of our large steel works are now using similar means to handle large masses, the application of this method to the handling of heavy guns could be readily tested.

A battery of twelve guns, mounted as indicated (Sheet IV), could deliberately fire six shots per minute; or a ship in a channel, with one of these batteries on each side, would receive a shot every five seconds, without a reasonable chance of doing much damage by returning the fire, as both guns and gunners would be invisible, except the gun at the instant of firing. That the moral as well as the physical effect of such a fire would be very great can hardly need a demonstration.

If compressed air be used instead of liquid pressure, the accumulator should be replaced by a large and strong tank of boiler iron, and the pumps, pipes, &c., would require corresponding adaptation, but the general arrangement would be similar to that described.

VII.—Estimates of Costs.

After the experimental firing by General Hunt's Board, I requested Messrs. Paulding and Kemble, of the West Point Foundry, to make an estimate of what they would build such carriages for, and after sending their engineer, the late Mr. Rumpf, a well-known expert in such matters, to inspect the carriage as it then stood at Battery Hudson, they replied that they could make them for $5,200 each, complete in all respects, except furnishing the counterpoise. This latter would cost $450, making in all $5,650.

General Gillmore also made at the same time a detailed estimate of the cost of preparing the well, platform, and other parts of the emplacement, which amounted to $4,672, or $1,884 more than for the old carriage.

At that time the prices of such work were very much higher than at present, in many items fully double. Pig-iron cost $40 per ton, but now brings only $18 to $20. Bar iron cost $80 then, but $35 to $40 now. Steam-engines and other like machinery have also become about 50 per cent. cheaper.

In addition to this, the carriage at that time contained several heavy pieces of bronze or composition, which cost about 45 cents per pound, but the recent introduction of steel castings and forgings will enable those parts to be made fully as strong at less than one-sixth of the cost. For these reasons, and from experience in the use of metals and masonry for other purposes, I believe the following estimates could be safely relied on in building and mounting these carriages, provided, of course, a reasonable number is made at one time.

Cost of each carriage for a 25-ton gun, complete, including rope, counterpoise, &c.	$4,000
Same for a 50-ton gun	6,000
Cost of boilers, pumps, accumulator, and pipes, for a 12-gun battery, $8,760, or per gun	730
Cost of hydraulic cylinders and other attachments to each carriage for traversing, &c., say	600
Total cost for a 50-ton gun	7,330

This would make the entire cost of carriages, ropes, counterweights, and hydraulic machinery for a 12-gun battery of 50-ton guns $87,960.

For the special cost of the counterpoise system it would be necessary to deduct the cost of ordinary carriages for this caliber of guns, for which I have no data available.

The additional cost for wells, breast-height walls, platforms, &c., will not exceed the estimate of General Gillmore already given for the 15-inch gun, viz: $1,884 per gun, or for the battery $22,608.

The cost of parapets, traverses, magazines, &c., which constitute the fort proper, will probably be about the same whatever system of mounting guns, *en barbette*, is adopted.

In conclusion, I can probably give no better account of the advantages of the counterpoise system than by the following extract from a letter referred to me about eight years ago by the Chief of Engineers:

ENGINEER OFFICE,
New York, December 11, 1877.

GENERAL: * * * I doubt if barbette guns, exposed above the parapet in the usual manner, could be served at all—unless distributed over a very long line—in the presence of two or three armored broadsides firing shells, grape, canister, and lead bullets from mitrailleuses at short range.

It is needless to say that unless we can serve our guns, channel torpedoes are of no value, and the whole defense becomes worthless.

It seems desirable, inasmuch as our present dependence is upon barbette batteries, that we should have at least one gun in good working order, representing an efficient barbette system.

When it is remembered that the depressing carriage in Battery Hudson is the only one ever built after Major King's design, being in fact the first practical embodiment of his idea, applied by altering an old carriage, and that this old carriage, thus altered, sustained, in a satisfactory manner, a prolonged series of severe tests, by firing a sufficient number of service-charges to cover two or three engagements with a hostile fleet, and is still in a serviceable condition, the great value of the system, when perfected in some minor details, would seem to require no further proof. The trials developed no defect of principle.

* * * * * * * *

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieutenant-Colonel of Engineers, Brevet Major-General, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.,
Washington, D. C.

The following illustrations are appended:

Sheet I.—Shows the relative amount of cover afforded by the old and new systems, shaded space being that protected from direct fire arriving at an angle not greater than 5°.

Sheet II.—Shows the carriage for a 15-inch 25-ton gun, substantially as already built.

Sheet III.—Shows the carriage adapted to the 50-ton breech-loading guns.

Sheet IV.—Shows the general arrangement proposed for a 12-gun battery operated by steam-power.

Sheet V.—Shows the counterpoise carriage as built, in loading and firing positions (from photographs of a working model).

Respectfully submitted.

W. R. KING,
Major of Engineers, U. S. A.

CHATTANOOGA, TENN., *October* 15, 1885.

APPENDIX 4.

JOSIAH VAVASSEUR'S APPARATUS FOR CONTROLLING THE RECOIL OF ORDNANCE.

This invention has for its object improvements in apparatus for working and controlling the recoil of ordnance. For these purposes I employ dydraulic buffers, consisting of cylinders containing oil or other liquid, and pistons working within the cylinders. The piston is perforated or has passages cut on it longitudinally at its outer edge, and the piston-rod is attached to the gun-slide, so that on the recoil taking place the oil or liquid is compelled to pass through the passages in the piston, which passages are of comparatively small area. So far the arrangement does not present any feature of novelty; but according to my invention I cause the passages in the piston to be automatically and gradually closed during the recoil. The piston has a cover or valve perforated or provided with a passage or passages corresponding with the passage or passages in the body of the piston, but not necessarially of the same form.

The valve is loosely mounted, so as to turn or oscillate on the piston, and its turning is controlled in such a manner as to contract gradually and finally close the openings in the piston. The amount of contraction and the point at which the passages are closed by the oscillation can be regulated. The turning of the valve as the piston reciprocates is effected by means of projections formed on the valve, which work into helical or rifle grooves in the cylinder. The path or travel given to the valve being invariable, it is obvious that by partially rotating the piston the relative position of the passages in piston and valve and point of closing can be varied. To compensate for the varying space in the cylinder occupied by the piston-rod, I apply to the gun carriage a pair of hydraulic buffers so arranged that while the piston-rod of one is entering the cylinder that of the other is issuing from it, and I connect the cylinders by a pipe, by which means the fluid-space within the apparatus is maintained constant. I provide upon the pipe an automatic valve, which permits liquid to pass when the recoil takes place but prevents its return. I also provide a by-pass valve, which, on being opened, permits the gun to run out.

In the drawings, Figure 1 is a sectional plan of the apparatus. Fig. 2 is a section on the line A B in Fig. 1. Figs. 3 and 4 are transverse sections, to a larger scale, of one of the cylinders, showing the back of the piston and the cover or valve upon it. Fig. 5 shows the cover or valve separately.

A′ A^2 are the two cylinders, which are firmly attached to the gun carriage. A^x A^x are rifle or helical grooves formed in the cylinders. B′ B^2 are the pistons. B^x B^x are passages cut in their sides, by which the liquid may pass them. *b b* are the movable covers or valves on the pistons, which have projections *b′* entering the grooving of the cylinders, and passages are formed in them at b^x. C′ C^2 are the piston rods. D′ D^2 are brackets upon the gun-slide, in which the piston rods are fixed. E′ E^2 are glands at the ends of the cylinders, through which the piston-rods pass. F is a pipe connecting the cylinder A′ with the valve-box G, which is in communication with the cylinder A^2. H is a loaded valve in the box G, and I is a by-pass passage and valve.

On firing, the gun and carriage recoil, carrying the cylinders A′ A^2 with them, the liquid is driven past the pistons through the passages B^x, which are wide open at the commencement of the recoil, but are progressively closed or contracted by the covers or valves. The forms of the passages in the pistons and covers are such that a nearly uniform resistance is opposed to the recoil throughout until the gun is brought to rest. At the same time liquid is driven through the pipe F, and the valve H lifts. It closes again when the recoil ceases, and prevents the return of the gun. When it is desired that the gun should run out, the by-pass valve is opened.

In some cases I attach both piston-rods to the front end of the slide, a communicating passage being provided between the two cyliders. The cylinders are filled with liquid when the gun is in the firing position. In this arrangement no means are provided for compensating for the varying space caused by the withdrawal of the rods during recoil.

APPENDIX 5.

LIEUTENANT-COLONEL MALET'S PATENT GUN-CARRIAGE, DESIGNED FOR UNITED STATES GOVERNMENT. PATTERN, 5-INCH 30 CAL. B. L. R. GUN.

DESCRIPTION OF DRAWINGS.

The gun is mounted by its trunnions in a cradle formed of two side plates, *a a*. These plates are rigidly connected by the plate *b* and the bar *c*.

The main carriage consists of two plates, *d d*, secured to a circular base-plate, *e*, by angle-irons *f*. The cradle *a a*, with the gun, is slung therein by the links *g g g g*, so that when recoiling it can rise to the position shown by the red dotted lines in the side elevation.

The front of the carriage is closed by a plate, *h*, shown in section in the side elevation.

The hydraulic cylinder *i* is jointed to the bar *c* and the plate *h*, brackets J being provided to take the strain.

No means are shown of adjusting the resistance of the cylinder; but it may be of the same construction as that designed for the field gun-carriage.

The carriage traverses upon a central pivot, *k*, and the weight is carried upon a live ring of rollers, *l*, a clip ring, *m*, being provided to prevent the carriage rising. There is nothing special about this traversing mechanism. Any other arrangement may be employed.

An elevation of 20° and depression of 7° are provided for. A rack, *n*, having worm-teeth, is firmly affixed to the gun.

A bracket, *o*, is bolted to the plate *a*, and carries a shaft, *p*, and worm, *q*.

The shaft can slide within the worm, but is grooved at the upper end, and a feather provided in the worm, so that they must rotate together. The lower end of *p* has a bevel-wheel, *r*, keyed thereon.

The shaft *s*, with hand-wheel *t*, rotates in bearings fixed on plate *d*. It is grooved as shown at *s*, so that the bevel-wheel *u*, which is provided with a feather, rotates with it but can slide freely thereon.

The casting *v* keeps the two bevel-wheels accurately in gear.

When the gun recoils the wheels slide up the shaft *s* to the position shown by the red dotted lines, and the sliding motion of the shaft *p* allows for the curved path described by the plate *a*.

The advantage of this elevating gear is that the hand wheel *t* is wholly unaffected by the recoil of the gun, whilst the gun remains firmly secured in the angle of elevation required.

Another hand-wheel may conveniently be attached to the other plate *d*, and communicate with any ordinary mechanism for traversing the gun by means of a worm ring, *w*.

The small elevation to ½-inch scale gives a view of the external appearance of the gun, showing how complete the gear is protected from injury by machine-guns or otherwise. This carriage has been specially designed for use on a deck or other exposed position.

NEW YORK, *October* 15, 1885.

INDEX.

Page.

Abbot, Lieut. Col. Henry L., Corps of Engineers, member of the Board 5
Appropriations recommended, purpose, first year, future annual 29
Armament of ports, proposed armament ..... 13 *et seq.*
Armament and mountings for land defenses, estimate 24
Armor, reports upon. (*See* Committees, reports.)
Armor, steel:
  Difficulties in obtaining 25
  Will replace both iron and compound 34
Armor plates:
  Experimental targets, trials, and results 48
  Iron and compound, report 277
Armor and guns, report of Committee No. 4 as to the capacity of steel works of the country 257
Baltimore, proposed armament of 16
Batteries, floating:
  Estimate for, including armament 24
  Appendix to report of Committee No. 5 305
Benét, Brig. Gen. Stephen V., Chief of Ordnance, member of the Board 5
Board on fortifications or other defenses:
  Personnel 5
  Its estimates consolidated 28
Boats. (*See* Submarine and Torpedo Boats.)
Boston, proposed armament 14
Brewer, A. T., counterpoise platform 363
Buffington, Lieut. Col. A. R., proposed depressing gun-carriage 367
Canals, statistics of 236
Carriages. (*See* Gun-carriages.)
Cast iron:
  Advocated by some solely on account of supposed cheapness 10
  Comparison between cast-iron and steel 12-inch rifles 11
Characteristics of foreign ships of war (data) 105
Charleston, S. C., proposed armament 17
Coast-defense vessels, general features of various, for coasts, lakes, harbors, &c., gunboats and torpedo-boats 319, 329, 337, 345, 351, 355
Committees, reports:
  Report of Committee No. 1, to collect information and report upon the various kinds of armor, the penetration and effects of shot upon armor and earth, and guns and their ranges 31
  Report of the subcommittee of Committee No. 1, on armor, armament, ranges, &c. 34
  Report of Committee No. 2 (appendix to report of Committee No. 1), to collect information and report upon torpedoes, stationary, movable, and torpedo-boats 67
  Submarine boats. (Appendix to report of Committee No. 2) 75
  Report of Committee No. 3, to collect information and report upon ships of war, their armor, armament, and draught of water; also the navigable draught of entrances of the ports of the country 101
    Inclosure A.—Characteristics of principal foreign ships of war 105
    Inclosure B.—Depths of water on bars 160
    Inclosure C.—List of vessels classified according to draught of water and ports which they can enter 163
    Inclosure D.—Characteristics of principal ports 171
    Inclosure E.—Study of exposed points on our frontiers 195
  Report of Committee No. 4, to collect information and report upon the capacity of the country to furnish armor and guns, and the steps necessary to enlarge it 257
    Appendix A.—List of steel works as reported to August, 1885, to American Iron and Steel Association 273
    Appendix B.—Iron and compound armor plates 277

Page.

Committees, reports—Continued.
Report of Committee No. 6, to collect information on gun-carriages 359
Appendix 1.—Description of Brewer's counterpoise platform 363
Appendix 2.—Proposed depressing gun-carriage 367
Appendix 3.—The counterpoise gun-carriage of Maj. W. R. King, Engineers 371
Appendix 4.—Josiah Vavasseur's apparatus for controlling recoil 385
Appendix 5.—Lieutenant-Colonel Malet's patent gun-carriage 387
Compound armor plates 277
Contracts for these purposes should be for a series of years 30
Corning, Erastus, member of the Board 5
Cumberland Sound. (*See* Fort Clinch.)
Defenses:
Ports where most urgently needed 8
Accessories 8
Fixed and floating 9
Torpedo-boats 13
Land, estimates for, without armament 21
Land, estimates for armament 24
Depth of water on bars 160
Endicott, Hon. W. C., Secretary of War, president of the Board 5
English ship and coast B. L. and M. L. cannon, data 38
Estimates:
For land defenses without armament 21
For land defenses, armament 24
Submarine mines, &c 25
Torpedo-boats 25
Plant for making steel 26
Plant for fabrication of guns 26
For defenses, recapitulation of estimates 28
Exposed points on our frontiers 195
Floating batteries, estimate for armament, &c 24
Floating batteries (by Commander W. T. Sampson, United States Navy) 305
Fort Clinch, proposed armament 19
Fort Popham, proposed armament 19
Fort Knox, proposed armament 20
Foreign ships of war, characteristics of 105
French ship and coast B. L. cannon 42
Foundries:
(Steel works) list of in the United States 273
Report on capacity of the country to furnish armor and guns (Committee No. 4) 257
Frontier, study of exposed points 195
Galveston, proposed armament 18
General and particular features of coast-defense vessels 319, 329, 337, 345, 351, 355
Goodrich, Commander Caspar F., U. S. Navy, member of the Board 5
Guns:
The Rodman smooth bore, the largest prior to 1860 5
How they can be obtained, methods limited 25
Estimate for plant for fabrication of 26
Report of Committee No. 4 on capacity of the country to furnish armor and guns 257
Report of Committee No. 1, ranges, penetration, armor, effects of shot on armor, earth, &c 31
Gun-carriages:
Report of Committee No. 6 359
Brewer's counterpoise platform 363
Proposed depressing gun-carriage 367
The counterpoise gun-carriage designed by Maj. W. R. King, United States Engineers 371
Lieutenant-Colonel Malet's patent (pattern 5-inch, 30 cal., B. L. R. gun) 387
Gun-boat, harbor-defense, general features of a light draught, designed for service in shallow waters, &c 345
Gun-Foundry Board, its conclusions in its supplementary report of December 20, 1884, indorsed 27
Hampton Roads, proposed armament 15
"Haskell" multicharge gun, not recommended 12
Iron and compound armor plates 277
Kennebec River (*see* Fort Popham) 19
Key West, proposed armament 17

Page.
King, Maj. W. R., Engineer Corps, design of counterpoise gun-carriage 371
Krupp steel guns as compared with cast-iron 11
Krupp ship and coast B. L. cannon, dimensions, weights, &c 38
Lake ports, proposed armaments 15
Land defenses:
Estimate for, without armament 21
Estimate for armament 24
Recapitulation of estimates 28
List of steel works in the United States 273
Machine guns 10
Maguire, Capt. Edward, Corps of Engineers, submarine boats 75
Malet, Lieutenant-Colonel, patent gun-carriage 387
Merchant marine of the United States 227
Mines, submarine:
Estimates for 25
Report of Committee No. 2 67
Mobile, proposed armament 17
Morgan, Joseph, jr., member of the Board 5
Movable torpedoes, report of Committee No. 2 ..... 10, 71
Multicharge guns, the Haskell and Ripley 12
New Bedford, proposed armament 20
New Haven, proposed armament 20
New London, proposed armament 18
New Orleans, proposed armament 16
New York, proposed armament 13
Newton, Brig. Gen. John, Chief of Engineers, member of the Board 5
Penetration of shot upon armor and earth (report of Committee No. 1) 31
Penobscot River (*see* Fort Knox) 20
Pensacola, proposed armament 19
Philadelphia, proposed armament 16
Ports:
Where defenses are most urgent 7
List of, with their defenses 13
Proposed armaments ..... 13 *et seq.*
Ports of the United States, characteristics of 171
Portland, Me., proposed armament 17
Portland, Oreg., proposed armament 18
Portsmouth, N. H., proposed armament 19
Projectile, nature of, must vary according to the target 12
Projectiles must be made of steel 34
Proposed coast-defense vessels, general and particular features. (*See* Coast-defense vessels.)
Railways, coast, rolling stock of 232
Rapid-firing guns 10
Recoil, Josiah Vavasseur's apparatus for controlling 385
Reports. (*See* Committees.)
Rhode Island ports, proposed armament 17
"Ripley" multicharge gun, not recommended 12
Rodman smooth-bore guns, the largest prior to 1860 5
Rolled steel projectiles 12
Rolling stock of coast railways 232
Russian ship and coast B. L. cannon, dimensions, weights, &c 42
Sampson, Commander W. T., member of the Board 5
Sampson, Commander W. T., United States Navy, floating batteries 305
San Diego, Cal., proposed armament 19
San Francisco, Cal., proposed armament 13
Savannah, Ga., proposed armament 18
Sea-coast guns, number available 20
Ships, list of, classified, their draught, and ports capable of entry 163
Ships of war:
Foreign, data of characteristics 105
Number building and completing belonging to England, France, Germany, Italy, and Russia 313
General features of a first-class coast-defense vessel 319
General features of a first-class coast-defense vessel with special reference to service in Chesapeake Bay 329
General features of a second-class vessel designed for general service on coasts and for offensive operations 337

Page.

Ships of war—Continued.
Harbor-defense gun-boat for service in shallow waters 345
Lake, river, and harbor gun and torpedo boat 351
Particular features of proposed coast-defense vessels 355
Shipping of the United States (commercial) 227
Shot (report of Committee No. 1), effects upon armor and earth, &c 31
Smith, Capt. Charles S., Ordnance Department, member of the Board 5
Spanish rifled B. L. cannon; dimensions, weights, &c 42
Stationary torpedoes (report of Committee No. 2) 67
Steel for guns emphatically recommended 11
Steel guns compared with cast iron 11
Steel, report of Committee No. 4, on capacity of the country to furnish, for armor and guns 257
Steel works, list of, and capacity in United States 273
Steel armor promises to replace both iron and compound 34
Submarine boats, not yet passed the experimental stage 13
Submarine boats (appendix to report of Committee No. 2) 75
Submarine mines:
Personnel 10
Estimates for 25
Report of Committee No. 2 67
Tables (report of Committee No. 1):
Kinds of armor, penetration, and effects of shot; guns, their dimensions, ranges, &c.:
TABLE I. Krupp ship and coast B. L. cannon 38
English guns 38
Spanish 42
French 42
Italian (coast) 42
Russian 42
TABLE II. The actual ranges and accuracy of fire obtained in practice with heavy rifled cannon (Krupp, Italian, Armstrong) 44
TABLE III. Material dimensions, weights, &c., of experimental armor plates or targets, with results of fire 48
TABLE IV. Showing the actual penetration of rifled cannon into earth, granite, concrete, &c 60
TABLE V. Showing the calculated penetration of rifled cannon into clay, sand, and granite 62
TABLE VI. Armor-plated revolving turrets (chilled cast iron) prepared and in construction at the Gruson Works on the account of various countries 63
Tables (report of Committee No. 3):
Ships of war, their armor, armament, draught, &c.:
Depths of water on bars, ports of United States 160
Foreign ships of war drawing 25 feet and over 165
from 20 to 25 feet 165
from 15 to 20 feet 166
less than 15 feet 167
Foreign ships of war, characteristics of:
Argentine Republic 154
Austria 144
Brazil 152
Chili 154
China 154
Denmark 148
England 106
France 118
Germany 138
Greece 150
Holland 146
Italy 128
Japan 156
Norway 148
Portugal 152
Russia 132
Spain 142
Sweden 150
Turkey 150
Guns afloat, ranging 9 and 10 miles and upwards 102, 103

Page.

Tables (Report of Committee No. 3)—Continued.
Canadian frontier defense, &c.:
Canadian frontier railroads ..... 200 *et seq.*
Canadian navigation and shipping 211
Gunboats, &c., of English navy available for service on the Lakes 213
Richelieu and Lake Champlain navigation system 199
Saint Lawrence navigation system 197, 198
Trent River navigation system 199
United States coast traffic, water and rail:
Canals of United States, statistics 236
Coast railways of United States, rolling stock 232
Merchant steam tonnage and traffic on United States waters with navigable outlet 227
Number and tonnage of sailing vessels, steamers, &c., engaged in cod and mackerel fisheries, year ending June 30, 1884 228
Number and tonnage of vessels on Pacific coast June 30, 1884 254
Pacific coast railways of United States, rolling stock 254
Tables (report of Committee No. 4):
Steel for guns and armor:
Armor required for turrets and casemates 262
Armor required for Navy 262
Guns for New York, Philadelphia, Boston, Baltimore, and other ports ..... 260 *et seq.*
Number of guns and mortars proposed for coast defense by Armament Board, 1884 260
Production of iron and steel, 1884 258
Size of forgings for guns of present designs 262
Compound armor abroad:
Armor plates, trials in England, 1877 and since, Cammell and Brown plates 283, 290, 292, 293, 294
Armor plates, trials at Spezzia, 1882, Cammell, Brown, and Schneider plates 298
Physical tests of iron and steel bars taken from armor plates after artillery tests, Spezzia, 1882 299
Steel for compound armor, chemical composition of 282
Tables (appendix to report of Committee No. 5):
Floating batteries:
Cost of coast defense vessels for Long Island Sound, Hampton Roads, Mississippi Passes, and San Francisco 312
Dry-docks in United States of more than 58 feet breadth, their dimensions, &c 317
Vessels building and completing, England, France, Germany, Italy, and Russia, United States ports which they can enter, their armor, armament, &c 313
England 314
France 315
Germany 316
Italy 315
Russia 316
Torpedoes, movable (report of Committee No. 2) 71
Torpedoes, stationary (report of Committee No. 2) 10, 67
Torpedoes, aerial, not yet practically considered 13
Torpedo-boats, useful for offensive and defensive operations 13
Torpedo-boats (report of Committee No. 2) 73
Torpedo-boats, estimate for, for defenses 25
Torpedo-boats, *personnel* 13
Vavasseur's, Josiah, apparatus for controlling recoil of ordnance 385
Vessels. (*See* Ships of war.)
Washington, proposed armament 16
Water, depths of, on bars (table of ports) 160
Wilmington, N. C., proposed armament 19